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ORIGINAL ARTICLES.

On New Carboniferous Gastropoda from the Isle of Man.

By John Weir, M.A., Ph.D., Geological Department, University of Glasgow.

(PLATE XIX.)

THE fossils described in the following pages were collected by Mr. James L. Begg, The Elms, Mount Vernon, Glasgow, from the Poolvash Limestone, Balladoole, Isle of Man. The fauna of these limestones, according to Dr. Wheelton Hind,[1] indicates an upper *Dibunophyllum* age. The most recent and most complete list of Carboniferous Limestone fossils from the south of the I.O.M. is that published by Mr. John Smith,[2] and compiled from the Survey list, from Dr. Hinde's list, and from Cuming's list, as well as from Mr. Smith's own collection. In addition to the new forms described in this paper, Mr. Begg's collection contains the following species not listed by Mr. Smith :—

Scalites tabulatus (Phill.) ; *Ptychomphalina tornatilis* (Phill.) ; *Pt.* cf. *pyramidalis*[3] (de Kon.) ; *Tychonia omaliana* (de Kon.) ; *Glyptobasis pumila*, de Kon. ; *Murchisonia verneuiliana*, de Kon. ; *Straparollus placidus*, de Kon. ; *Phanerotinus serpula* (de Kon.).

Mr. Begg's collection contains a specimen, illustrated Pl. XIX, Fig. 7, which is near *Tychonia omaliana*,[4] but is more depressed in general form. The spire is practically non-existent, and the body-whorl is sub-discoidal, not sub-globular as in *T. omaliana*. The aperture is oval, its long axis perpendicular to the length of the shell. The columella is obscured by matrix, and is not determinable. The surface is devoid of ornamentation, except on the base, where close to, and concentric with the columella, there are two or three striae.

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[1] *Proc. Yorkshire Geol. Soc.*, N.S. xvi, 1907, p. 150.

[2] *Trans. Geol. Soc. Glasgow*, xiv, part 2, 1911, p. 149.

[3] A stouter shell than *Pt. pyramidalis* ; spiral angle 61°.

[4] De Koninck, L. G., 1881. " Faune du Calcaire Carbonifère de la Belgique," *Ann. Musée Hist. Nat. Belgique*, vi, p. 8, pl. i, figs. 17–20.

Dimensions.—Height, 10 mm. ; breadth, 18 mm. (approx. : the greatest width of the shell involves the outer lip, which is fractured).

DESCRIPTION OF THE SPECIES.

Genus NATICOPSIS McCoy.

Naticopsis variata (Phill.).

Naticopsis variata McCoy, 1855. " British Palaeozoic Fossils," p. 544.

Mr. Begg's collection contains six specimens which resemble *N. variata* in form, but differ in ornamentation. The shell-structure is somewhat lamellose, there are no closely set transcrescent striae, and the plicistriation of the sutures is absent.

Genus MOURLONIA de Kon.

Mourlonia monensis, n. sp. (Pl. XIX, Figs. 1 and 2.)

Diagnosis.—Shell trochoid ; spire of five slightly convex whorls ; suture sharply incised ; sinus-band peripheral in body whorl, coincident with suture in earlier whorls, and limited above and below by small but well-defined keels ; ornamentation of fine spiral (transcrescent) and axial (concrescent) ribs, intersecting to form a beaded reticulation ; below the suture there is an impressed area, consisting of two spiral ribs, rather larger than the others, but beaded in the same way by intersection with the concrescent elements of the ornamentation ; band ornamented with transverse, sickle-shaped ribs.

Dimensions.—Height, 11 mm. ; breadth, 11 mm.

Remarks.—The aperture is not preserved in the two specimens collected by Mr. Begg, but it was probably sub-circular, with the outer lip flattened towards the suture. The umbilicus is filled with matrix in both specimens, and is not determinable.

The exposed surfaces of the early whorls are moderately convex, but this small degree of convexity is lost in development, and the last whorls are almost flat on their exposed surfaces. The characteristic ornamentation of the species is due to the local bead-like thickening of the intersections of the concrescent and transcrescent ribs. Even as late in ontogeny as the third whorl, the concrescent element is the only one present. The transcrescent ribs appear in the fourth whorl and develop rapidly, the final beaded reticulation being quickly attained. The concrescent ribs are inclined obliquely backwards over the surface of the whorl towards the band, and the character of the ornamentation remains unchanged over the base of the shell. This species is nearly related to *M. subconoidea* [1] de Kon., and may be derived from it. De Koninck's species has a smaller spiral angle, wider suture, and more convex whorls. The two species differ also in ornamentation and in the character of their sinus-bands. In respect of these two units *M. monensis* is biologically more advanced. The delicate concrescent ribs of *M. conoidea* are similar to the concrescent ribs which constitute the only ornamentation of the early whorls of *M. monensis.* The band of *M. conoidea* is a broad, flat, rather shallow groove ; in *M. monensis* it becomes arched up into a rounded ridge between the marginal keels, from which it is separated by two well-defined furrows.

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[1] Loc. cit., viii, 1883, p. 90, pl. xxxii bis, figs. 28–31, and pl. xxxiii bis, figs. 15–17.

M. monensis resembles *Pleurotomaria thyrrena* Gemmellaro[1] in ornamentation, and in the character of the sinus-band, but its general form is entirely different. In the Italian species the whorls are more convex, the body-whorl is relatively larger and more globose, and the spire is shorter.

Genus POLYTREMARIA d'Orb.

Polytremaria beggi n. sp. (Pl. XIX, Figs. 3 and 4.)

Diagnosis.—Shell depressed-trochoid, consisting of six moderately convex whorls ; suture well marked, but only very slightly impressed ; sinus-perforations not peripheral on the body-whorl, but situated on the lower part of the upper surface of the whorl, and defined by a slight thickening of their margins ; ornamentation of transcrescent ribs, gently flexuous in conformity with the undulations of the perforation-margins ; the two posterior ribs in the whorl are crossed by concrescent ribs, the intersections giving a tuberculate ornament to this part of the whorl ; sutural angle, 91° ;[2] spiral angle, 112°.[2]

Dimensions.—Height, 6·5 mm. ; breadth, 11 mm.

Remarks.—The genus *Polytremaria* was created by d'Orbigny in 1850[3] for the reception of the species *Pleurotomaria catenata* de Kon. The diagnostic feature of the genus is the series of perforations, morphological equivalent of the sinus-band in other *Pleurotomariidae,* produced by the alternate closing and opening of the sinus during growth. *P. catenata* is the only species of *Polytremaria* known hitherto. It is very rare at Visé, and has been recorded from Lowick, Northumberland, by Bigsby.[4] De Koninck is inclined to doubt this occurrence, however.[5]

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[1] " Fauna de' Calloari con Fusulina della Valle del Fiume Sosio," *Gionale di Scienze Naturale di Palermo,* xx, 1890, p. 102, pl. xix, figs. 31–33.

[2] As defined by Macdonald and Trueman, *Quart. Journ. Geol. Soc.,* lxxvii, 1921, p. 302. The term " spiral angle " is open to the objection that it is also used for the constant angle of a logarithmic spiral, and has already been used in that sense by Dr. Trueman with reference to the spiral coiling of *Gryphaea* (GEOL. MAG., LIX, 1922, p. 260). The " spiral angle " of a gastropod is not homologous with the angle which expresses the umbonal curvature of *Gryphaea.* Custom, however, probably justifies the retention of the term in the special sense of its application to gastropods.

[3] Prodrome, i, p. 122.

[4] Bigsby, J. J., 1878. *Thesaurus Devonico-Carboniferus,* p. 329.

[5] Loc. cit., viii, p. 10.

Polytremaria beggi is represented in Mr. Begg's collection by three specimens. It differs from *P. catenata* in several respects. The differences in the spiral and sutural angles—in *P. catenata* 76° and 100·5° respectively—cause differences in general form, the spire in *catenata* being more elevated and the whorls more oblique; the whorls in *catenata* are also more convex, giving a more deeply impressed suture. In *P. beggi*, between the perforations and the suture of the whorl there are four transcrescent ribs; the anterior one is tangent to the margins of the perforations, and the two posterior ones are crossed by concrescent ribs, as mentioned above. In the same region of the whorl in *catenata*, there are six or seven transcrescent ribs; the tuberculation at the suture is not specifically mentioned by de Koninck, but is shown in his enlarged figure. From this figure it would appear also that the perforations in *catenata* do not close up entirely, and that there is a marginal thickening forming lips; neither of these features is mentioned by de Koninck. In *P. beggi* the perforations close up entirely. The smallest of Mr. Begg's specimens shows a columella with one fold. The transcrescent ribs are continued over the base; both above and below they tend to lose their gently flexuous character as they recede from the perforations. None of the specimens has the aperture complete, but it would be oval, with the longer axis perpendicular to the axis of the shell.

I have named this species after Mr. Begg.

Genus PORTLOCKIA de Kon.

Portlockia cf. *blanda* (de Kon.). (Pl. XIX, Figs. 5 and 6.)

Pleurotomaria blanda, de Kon., 1851. Desc. des Anim. Foss. Terr. Carb. Belgique, *Supplement*, p. 694, pl. lviii, fig. 6.

Ptychomphalus blandus, de Kon., 1883. Calc. Carbonifère de la Belgique, p. 48, pl. xxv, figs. 41-44, and pl. xxxi, figs. 4–6.

Diagnosis.—Shell obtusely turreted, turbinate; spire of five whorls which are only very slightly convex, almost flat; suture well marked but not deeply impressed; aperture sub-oval, with longer axis parallel to the axis of the shell; ornamentation of transcrescent ribs, six in each whorl, beaded by the intersection of much finer concrescent ribs, from which the beading characteristic of the upper parts of the whorls is absent.

Dimensions.—Height, 11 mm.; breadth, 7·5 mm.

Remarks.—This form is represented in Mr. Begg's collection by two specimens, in a very beautiful state of preservation. In one the outer lip is absent; in the other it is slightly fractured, but this does not obscure the general character of the aperture.

Transcrescent ribs are the first element of the ornamentation to appear. Concrescent ribs are introduced on the second whorl, and at their intersections with the transcrescent ornament produce the characteristic beading. This differs in several important respects from that described above in *Mourlonia monensis.* Superficially the essential reticulate character of the ornament is not so obvious in *P.* cf. *blanda,* because of the relative fineness of the concrescent element. In *M. monensis* this is introduced first. The transcrescent ribs are introduced later, but develop more rapidly, and ultimately become almost equal in size to the concrescent. In *P.* cf. *blanda* the transcrescent are introduced first and always remain much stronger than the others. There is, therefore, a tendency to transversal homeomorphy between these two species in respect of this unit character, a tendency which would find complete expression if there were a progressive acceleration in the development of concrescent ribs in *P.* cf. *blanda.* The history of the development of reticulate ornamentation in the individual has proved to be a differential character of fundamental importance between certain Liassic species of *Procerithium,* which have a zonal value.[1] In the present instance it has no such value, but it is interesting to observe how two species representing totally unrelated stocks, develop the same type of ornamentation by quite different sequences of events.

This form is stouter than *Pt. blandus,* as described and figured by de Koninck; the latter is more turreted and its whorls are more convex; they are also more oblique, owing to the greater sutural angle. The ornamentation in the two forms is identical in its full expression, but I have not been able to study its development in the Viséan form. In a footnote to the explanation of plate xxv, de Koninck says that *Pt. blandus* may belong to the genus *Portlockia.* This is probably correct. The I.O.M. specimens have certainly no affinity with *Pleurotomaridae.*

P. blanda is similar to *P. semicancellata* de Kon.[2] Both are very rare at Visé. In *semicancellata* the perfect equality of the concrescent and transcrescent elements, and the narrowness of the intervening furrows gives to the ornamentation the character of a regular tuberculation. A reticulation, on the contrary, requires relatively wide separating furrows and narrow ribs, and is emphasized by a slight discrepancy between the transcrescent and concrescent elements in the degree of their development. Like *P. blanda, P. semicancellata* has only transcrescent ribs on the base of the shell. It is a stouter, more turbinate shell than *P. blanda.*

Genus SCALITES Emmons.

Scalites ambiguus, n. sp. (Pl. XIX, Figs. 8 and 9.)

Diagnosis.—Shell sub-fusiform anteriorly, composed of three whorls which are flattened above, and do not form a spire; body-whorl posteriorly globular, the upper surface passing anteriorly by a gradual curve into the lower, thence into the fusiform columella;

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[1] Macdonald and Trueman, loc. cit., pp. 306–307.

[2] Loc. cit., vi, 1881, p. 84, pl. ix, figs. 32, 33.

aperture sub-triangular, with apex anterior; outer lip sinuous; shell substance lamellar, the edges of the lamellae forming growth-lines, which are sinuous in conformity with the outer lip.

Dimensions.—Height, 5·5 mm.; breadth, 5·5 mm.

Remarks.—This species is represented in Mr. Begg's collection by a single specimen, beautifully preserved. I refer the species to the genus *Scalites* with some doubt, because of the peculiar lamellar structure of the test, and the absence of a spire composed of the characteristic step-like whorls. The flattened upper surfaces of the whorls in the present specimen merge gradually into each other, to form a regularly dome-shaped summit to the shell. The upper surface of the whorl does not pass into the lower by a sharp right-angled keel, as generally in *Scalites*, but by a gradual, sweeping curve. This curve, and the similar curves of the earlier whorls, all fit closely into each other, thus eliminating the prominent " steps " at the sutures. The aperture is not quite intact in the only specimen available, but its nature is indicated by the growth lamellae. On leaving the suture of the body-whorl, these run first at right-angles to the suture, then curve backwards just where the upper surface of the whorl begins to curve into the lower; then they curve forward slightly on the lower surface towards the extremity of the columella. This sinuous course undoubtedly corresponds to a wide, asymmetrical sinus in the outer lip.

Scalites ambiguus most nearly resembles *Janthina issedon* Eichw., from the Carboniferous Limestone from the Urals;[1] it has a more fusiform body-whorl than the Russian species, and there is no trace of any transcrescent ornament; it is smaller (the dimensions of *J. issedon* are:—height, 17 mm.; breadth, 23 mm.), and the ratio height/breadth gives a stouter shell in *J. issedon*. It differs also in those respects in which it differs generally from the genus *Scalites*, in the synonymy of which de Koninck includes de Verneuil's genus *Janthina*.

I have to acknowledge my indebtedness to Mr. Begg for allowing me to study his interesting collection. Mr. Begg has also kindly prepared the drawings which illustrate this paper.

EXPLANATION OF PLATE XIX.

FIG.
1.—*Mourlonia monensis*, n. sp. × 4 (approx.).
2.— „ „ Details of ornamentation and sinus-band.
3 and 4.—*Polytremaria beggi*, n. sp. × 4 (approx.).
5.—*Portlockia* cf. *blanda* (de Kon.). × 4·5 (approx.).
6.— „ „ Ornamentation.
7.—*Tychonia* [near *Tychonia omaliana* (de Kon.)]. × 2 (approx.).
8 and 9.—*Scalites ambiguus*, n. sp. × 6.

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[1] De Verneuil, 1845, *Russia and the Ural Mountains*, ii, p. 341, pl. xxiii, fig. 5.

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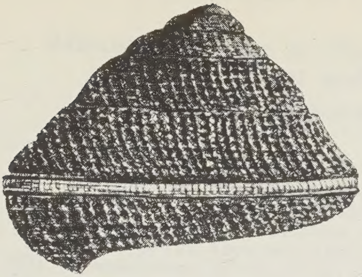

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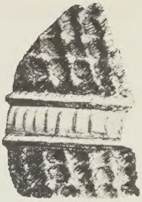

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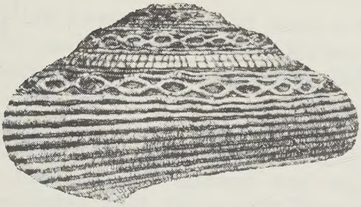

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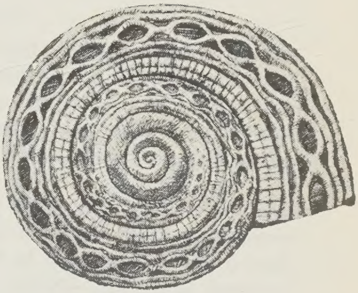

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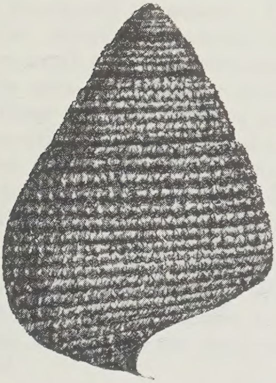

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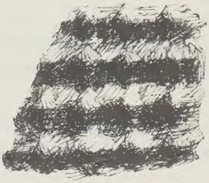

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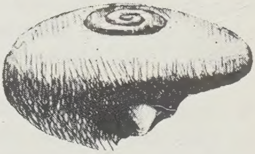

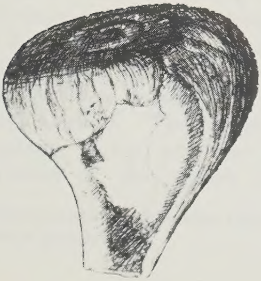

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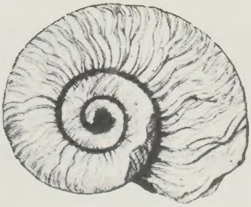

Photo. D. M. Filshill. *Del. T. L. Begg.*

NEW CARBONIFEROUS GASTROPODS FROM THE ISLE OF MAN.

[To face p. 438.

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Minor Structures in the Lower Greensand of W. Kent and E. Surrey.

By H. J. W. BROWN, M.Sc., A.K.C.

I. INTRODUCTION.
II. FOLDS IN THE LOWER GREENSAND.
III. RELATION OF THE GAPS TO LINES OF FOLDING.
IV. DEVELOPMENT OF THE RIVERS IN RELATION TO FOLDS.
V. ORIGIN OF THE DRY VALLEYS IN THE SEVENOAKS DISTRICT.
VI. FOLDS IN THE ADJACENT AREAS.
VII. OBSERVATIONS ON THE CAUSE OF THE FOLDS.
VIII. THE AGE OF THE FOLDS.

I. INTRODUCTION.

THE Lower Greensand forms a well-wooded range of hills in Kent and Surrey which is known in Kent as the Ragstone Range. Between Ashford and Leith Hill this range is broken by the consequent streams of the Stour, Medway, and Mole, and by the obsequent streams of the Shode, Oxted Brook, and that part of the Eden known as Gibb's Brook.

The Lower Greensand was originally surveyed by Topley who suggested that the major gaps might coincide with transverse synclines. A re-mapping of a large part of this area on the 6-inch scale by the writer has brought to light several structural features not previously recorded. These are intimately connected with similar structural features of the adjacent areas of the London Basin south of the Thames and the Central Weald. The topography of the area and the river development have largely been controlled by these minor structures and it has been possible to make some observations on their cause and age.

The following brief summary of the writer's work during the last four years may be helpful to those who are now making a more detailed study of small areas in the Weald.

II. FOLDS AND FAULTS IN THE LOWER GREENSAND.

(1)[1] Anticline trending W.N.W.–E.S.E. through Ulcombe and Boughton. This structure is proved by mapping the base of the Hythe Beds along the escarpment between Ulcombe and Liverton Street.

(2) Anticline through Maidstone and Broomfield. Inliers of Atherfield Clay at Caring Street and Leeds, and Weald Clay at Maidstone are aligned along an anticlinal axis trending W.N.W.–E.S.E. This structure consists of several small anticlines arranged *en echelon*.

(3) Syncline trending W.N.W.–E.S.E. through Loose and Great Chart, Ashford. The complementary syncline to the Ulcombe and Boughton Mount anticline is followed by the River Loose. The alignment of the outlier of Lower Greensand at Great Chart,

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[1] The numerals in brackets refer to map, the figures in black type to references at end of paper.

Ashford, suggests a continuation of the Loose Valley synclinal axis to this district.

(4) W.N.W.–E.S.E. anticline through Linton to the Medway gorge. Between Linton and the Medway gorge the strike of the Hythe Beds is W.N.W.–E.S.E. Mapping the base of the Hythe Beds between these places proves a southerly dip of the beds. North of Amsbury Wood the dip of the Hythe Beds is northerly. The structure dies out at the Medway gorge.

(5) Anticline trending W.N.W.–E.S.E. through Birchett Wood, Nettlestead. This structure is proved by mapping the base of the Hythe Beds in this district. The Medway breaks through the Lower Greensand escarpment between the Birchett Wood and Linton anticlines.

(6) E.–W. fault at Aylesford. This fault marked on the Geological Survey map is exposed in the Preston Hall Farm Quarry, Aylesford. In the north face of the pit occurs Folkestone sand. In the south face at the same level is gravel. This fault is probably connected with the anticline seen in the neighbouring Rag-pit at Allington (**14**).

(7) Anticline through Mereworth Wood and Barming Heath. Proved by a well-boring at the County Asylum, Barming, and by mapping the base of the Hythe Beds between the Shode Valley and Teston. The Medway between Teston and East Farleigh flows along the complementary syncline.

(8) N.N.W.–S.S.E. Syncline corresponding to the Shode Valley (**26**).

(9) E.–W. anticline between Hubbard's Hill and River Hill, Sevenoaks. Proved by mapping the Hythe Beds between these places.

(10) E.–W. anticline between Limpsfield and Ide Hill, Sevenoaks. Proved by mapping the base of the Hythe Beds between Oxted and Shode Valley. Inliers of Atherfield and Weald Clay at Crockham Hill Common, French St., Brook Place, and Whitley Forest near Ide Hill are brought up by this anticline.

(11) Transverse syncline at Oxted. The course of the Oxted stream through the Lower Greensand is determined by a transverse syncline, proved by mapping the base of the Hythe Beds between this stream and Gibb's Brook.

(12) Anticline trending E.N.E.–W.S.W. in the Vale of Holmesdale between Sevenoaks and Oxted.

This structure is visible in the Rag-pit at Sundridge and in lane sections at Brasted. By the topography of the area it can be traced as far west as Oxted, but its eastward extension is uncertain. Recent exposures suggest that this structure is a series of anticlines arranged *en echelon*.

(13) N.W.–S.E. fault, south of Godstone. This fault marked on the Geological Survey map is a normal fault with down-throw to the east. It has determined the course of Gibb's Brook across the Lower Greensand.

(14) E.–W. disturbance at Tilburstow Hill. The double escarpment at Tilburstow Hill may be due to reversed faulting as suggested by Professor A. H. Cox (**9**), or normal faulting to the south.

(15) E.–W. anticline through Bletchingley and Nutfield. Topley has shown there is a marked change of dip north and south of the Bletchingley and Nutfield road and has indicated this as a flexure (**2**, p. 234). It may be better considered as the northern limb of an E.–W. anticline.

(16) E.–W. anticline between Redhill and Reigate Park. The mapping of the Lower Greensand indicates a flexure in this area which is probably the northern limb of an E.–W. anticline.

(17) E.–W. flexure (that is the northern limb of a small anticline) in the neighbourhood of Park Farm, south-east of Dorking (**2**, p. 233).

(18) N.W.–S.E. fault at Betchworth (**2**, p. 233).

(19) E.–W. fault—the Rookery fault—north of Leith Hill between Westcott Heath and South Holmwood (**2**, p. 233).

(20) E.–W. anticline through Leith Hill (**2**, p. 232).

III. RELATION OF THE RIVER GAPS TO LINES OF FOLDING.

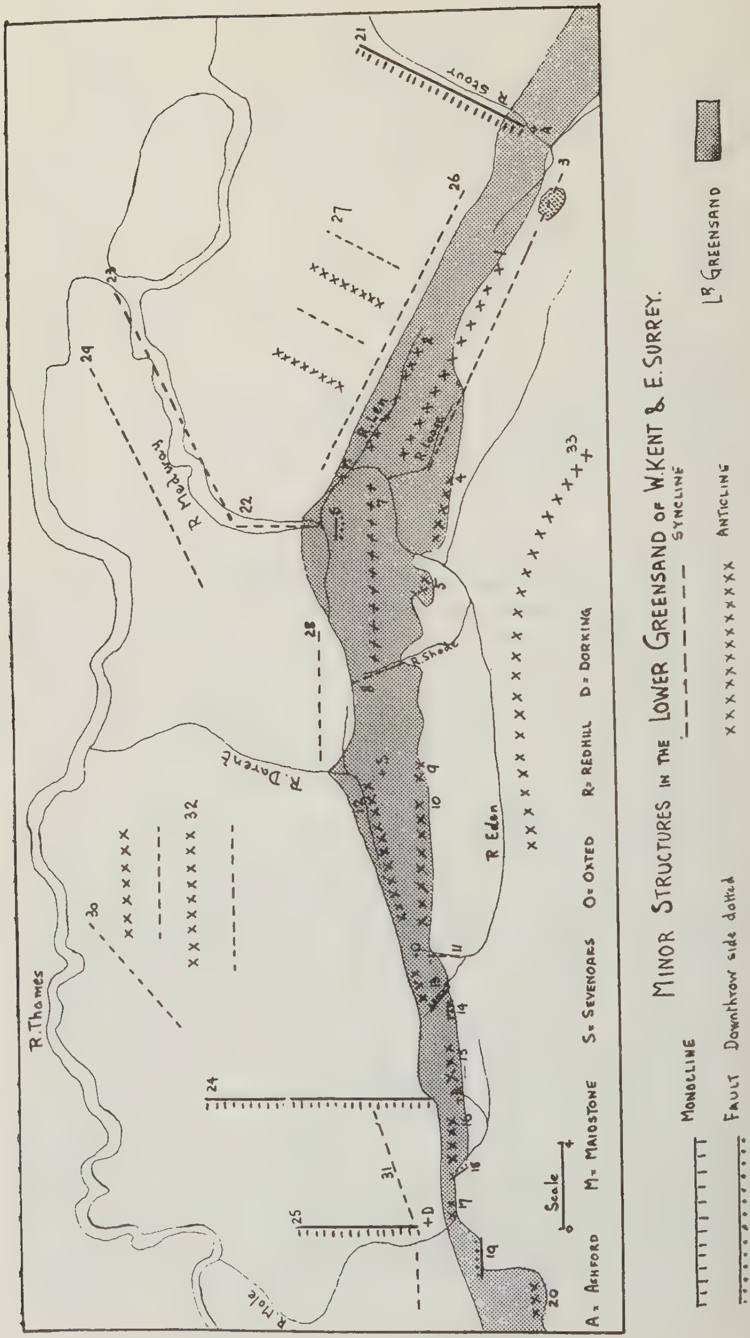
Topley has shown that east of the Stour gap there is a fall in the base of the Sandgate Beds along the strike between Mersham Street, south-west of Smeeth, and Willesborough, a distance of 3 miles, amounting to 130 or 140 feet (**2**, p. 277). Immediately west of the gap there is no evidence of a corresponding rise in the base of these beds. This gap corresponds more probably with a monoclinal fold than with a syncline (21). This fold has determined the course of the Stour between Ashford and Chilham. Between Chilham and Grove Ferry the course of the Stour may correspond with an anticline (**23**, p. 178.)

There is a N.S. syncline where the Medway enters the Chalk (22) (**4**). By plotting the base of the Gault at Chattenden, Frindsbury, and Chatham, evidence of a syncline is obtained which has determined the course of the Medway between Cuxton and Sheerness (23).

From Wrotham to Otford there is apparently a fall in the base of the Chalk suggesting a synclinal structure for the Darent Valley. This feature also marks a slight change in the trend of the Chalk escarpment. The probable prolongation of the Shode valley syncline in a north-westerly direction may have determined the course of the Darent north of Sutton-at-Hone.

The Croydon-Merstham valley corresponds to a structural feature probably a monocline (24). The sub-Eocene contours show a distinct difference of level east and west of the valley (**12**). This difference is borne out by the behaviour of the *Uintacrinus* band in the Chalk. The Blackheath Beds are not found west of the valley, and in this neighbourhood the change from the Woolwich to the Reading facies of the Lower London Tertiaries takes place.

The fault marked on the Geological Survey map at Merstham



MINOR STRUCTURES IN THE LOWER GREENSAND OF W. KENT & E. SURREY.

is not visible, but it is suggested by the marked change of strike of the Chalk, Upper Greensand, and Gault here. In this connexion a disturbance in the railway cutting at Merstham is recorded by Topley (**2**, p. 234).

The Mole gap corresponds to a structural feature, probably a monocline (25).

Borings at Cobham, Chobham, and Chertsey indicate a deepening of the London Basin west of this line. The boundary between the *Marsupites* and *cor-anguinum* zones of the Chalk is found at a lower level and nearer to the escarpment west of Leatherhead than to the east. The main outcrop of the Bagshot Sand terminates east of a north-south line through Leatherhead and the Thanet Sands are not found west of this line. Furthermore a marked change of lithology occurs in the Lower Greensand east and west of this line.

This structural feature has diverted the course of the Mole from a north-westerly course in the Weald to a northerly course through the Chalk. On leaving the Chalk at Leatherhead it resumes its north-westerly course again.

IV. Development of the Rivers in Relation to Folds and Faults.

The relation of the minor structures of the Lower Greensand to the subsequent streams of the Darent gives a clue to the former course of the River Wandle. The absence of Wealden pebbles in the Darent gravels proves that this river can never have extended far into the Wealden area.[1] It has been shown that the dry valleys of the Chalk dip slope between the Mole and Darent gaps are due to the recession of the Chalk escarpment in that area (**21**). The wind-gap north of Godstone probably originated in this way and its present level suggests that the stream it originally supported never extended beyond the Chalk escarpment, but the Croydon-Redhill valley, corresponding to an important structural feature, probably carried a stream from the Lower Greensand area. The stream that rises at Limpsfield may represent the head waters of the subsequent streams that drained the Vale of Holmesdale and entered the former River Wandle between Merstham and Redhill. A small subsequent stream may have entered it here from the west.

The gravel at Limpsfield Common, situated on the watershed between the Limpsfield stream and the River Darent, does not necessarily indicate a former westward extension of the latter river (**3**, p. 137).

This gravel may be of independent origin, but by regarding it as derived from a Tertiary outlier and associated with the flints from the Chalk and ironstone from the Lower Greensand its characteristics can be fully explained. The presence of a Tertiary outlier at Tandridge Hill $1\frac{1}{2}$ miles to the west supports this suggestion and Chalk flints are very common in the Vale of Holmesdale around Oxted (**11**).

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[1] "A few Wealden pebbles have been recorded from the Limpsfield gravel but they do not materially affect the argument." L. Treacher, "Report of Excursion to Limpsfield and Westerham": *Proc. Geol. Assoc.*, vol. xxi, 1908, p. 60.

The capture of the River Shode by the Medway has taken place along a transverse syncline. West of the Shode valley, the subsequent streams of the Darent are protected from the Medway by the Atherfield Clay, which here rises well above the level of the bottom of the Vale of Holmesdale. Farther west, at Oxted the Medway has captured the Limpsfield stream along a transverse syncline. At Godstone, Gibb's Brook is the result of river-capture of the Vale of Holmesdale stream along a transverse fault.

At Redhill the head waters of the former Wandle have been captured along a transverse fault by the Mole.

Between Redhill and Oxted the impervious beds of the Sandgate series play the same part in protecting the drainage of the Vale of Holmesdale as is played by the Atherfield Clay in the area farther to the east.

The presence of transverse folding and faulting in the Lower Greensand between Limpsfield and Borough Green, associated with a further recession of the Chalk escarpment between Sundridge and Kemsing, would produce in the Upper Darent basin a system of drainage and a topography which would be somewhat similar to that which exists farther to the west in the area between Purley, Redhill, and Oxted at the present day.

V. ORIGIN OF THE DRY VALLEYS IN THE SEVENOAKS DISTRICT.

Between Sevenoaks and Limpsfield, at Riverhead, Sundridge, Brasted, and Westerham, deep valleys have been carved into the dip slope of the Lower Greensand by streams draining to the River Darent. The heads of these valleys extend nearly to the escarpment but in no case do they breach it. Similar valleys occur east of Sevenoaks and west of Borough Green but, unlike those west of Sevenoaks, they contain no streams at the present day. These eastern valleys are similar in every respect to the western ones and evidently like them owe their origin to river action. The fact that they now support no streams is no doubt due to the lowering of the water-level in the valleys to a plane lower than the bottom of the valleys by the recession of the Lower Greensand escarpment.

These rivers, therefore, originated on the dip slope of the Lower Greensand, when the escarpment extended farther south and the Atherfield Clay stood at a higher level.

It has been shown that the dry valleys of the Chalk dip slope between the Mole and Darent gaps owe their origin to a similar cause (**21**).

On account of the Limpsfield-Ide Hill anticline the recession of the Lower Greensand escarpment here would have no effect on the water-level of the valleys of the western area. At some future time when the escarpment has receded north of this anticlinal axis the western valleys will become dry and resemble those in the eastern part of the area at the present day.

There is evidence in the neighbourhood of Kemsing to prove the absence of an east-west anticline near the escarpment. By plotting the base of the Hythe Beds at Kemsing, Fawke Wood, Seal, and Carter's Hill, Seal, it is found that the top of the Atherfield clay forms a northward-sloping surface with no sign of a southward dip at the escarpment.

It is significant that the head of the dry valley at Sevenoaks Common and the head of the dry valley at Knole Park, commence immediately east and west of the small east-west anticline at Hubbard's Hill and River Hill, Sevenoaks.

The dry valleys in the Lower Greensand of this area indicate that the Medway has cut back the escarpment at a greater rate than the rivers of the Lower Greensand have eroded their valleys. Such a type of river action suggests a recent uplift of the Weald Clay Vale, a fact which receives support in the Central Weald in the behaviour of the river Rother in cutting through its own alluvium (**19**, p. 147).

VI. FOLDS IN THE ADJACENT AREAS.

Between Maidstone and Ashford in the Lower Greensand there are three anticlinal axes trending E.S.E.–W.N.W., associated with small faults. The Chalk escarpment here coincides with the complementary syncline (26) to the Maidstone-Broomfield anticline. North of this area in the London Basin there are two sets of folds :—

(*a*) Folds trending N.E.–S.W. (27).—These folds dominate the dip slope of the Chalk plateau and Tertiaries between Chatham and Faversham (**1**, p. 350).

(*b*) Folds trending E.–W.—This type of folding occurs east of Whitstable and near the North Kentish Coast (**1**, p. 357).

Between Maidstone and Sevenoaks in the Lower Greensand the folding is mainly E.–W. with the N.N.W.–S.S.E. Shode Valley syncline. Between Kemsing and Wrotham the Chalk escarpment trends E.–W. and probably corresponds to a structural feature, but east of the latter place the change in direction of the escarpment is the result of erosion by the Medway along a transverse synclinal valley. By plotting the base of the Lower Greensand at Kemsing and Seal evidence of an increase of dip towards the escarpment is obtained (28) (**27**, p. 10).

North of the Thames at Billericay the Medway syncline is continued by an important structural feature described as a fault by Professor P. G. H. Boswell (**8**, p. 550) and as a monocline by S. W. Wooldridge (**23**, p. 179).

North of Maidstone and Sevenoaks in the London Basin there is a N.E.–S.W. syncline from Cobham to All Hallows (29), in which the Lower London Tertiaries are preserved (**23**, p. 177). In the area towards the Darent definite information of the trend of folding is lacking, but south of Gravesend it probably follows E.–W. lines.

Between Sevenoaks and Leith Hill the predominant folding of the Lower Greensand is E.–W. in direction. Between Dunton Green and Oxted the trend of the Chalk escarpment is parallel to the minor folds in the Vale of Holmesdale in this area. Here the average dip of the Chalk along the escarpment is 5° N., but the average regional dip of the Chalk, which is not easy to obtain, appears to be 2° or even less (**21**, p. 106). West of Oxted the trend of the Chalk escarpment is broken by embayments at Merstham and Pebble Combe, but it has not been possible yet to associate these definitely with structural features.

In the London Basin north of Sevenoaks and Dorking and south of the Thames detailed knowledge of the minor structural features is obtainable.

They may be summarized :—

Folds trending N.E.–S.W. (**17**, p. 4, **23**, p. 176).

Shooters Hill—Crystal Palace syncline (30).
Deptford—Wimbledon Fault.
St. Johns—Beckton Fault.

A suggested flexure for the Headley, Chipstead, and Polesden Valleys (**10**), (31).

Folds trending N.W.–S.E. (**17**, p. 4) (**23**, p. 176).

Selhurst Anticline.
Chislehurst Anticline (**14**).
Ewell and Thames Ditton Anticline.

Folds trending E.–W. (**1**, p. 319), (**23**, p. 176), (32).

A series of E.–W. folds in the Chalk can be traced from the Croydon-Redhill valley probably as far west as Gravesend.

The line of the Croydon-Redhill flexure may be continued north of the Thames by the suggested Lea Valley monocline.

To the south in the Central Weald an anticlinal axis associated with faulting runs W.N.W.–E.S.E. through Horsmonden and Brenchley to Pembury (33). West of this latter place the axis is almost due E.–W. (**2**, p. 222).

VII. Observations on the Cause of the Folds.

If the structural features of the Lower Greensand and adjacent formations are represented on a map three dominant sets of structures may be distinguished :—

(*a*) Folds having a marked parallelism with the regional strike of the Lower Greensand and Chalk.
(*b*) Folds trending N.E.–S.W. or S.E.–N.W.
(*c*) Folds trending N.–S.

The flexures with a marked parallelism to the regional strike of the outcrop predominate. East of Maidstone this strike is E.S.E.–W.N.W. West of Maidstone it is almost due E. and W. Throughout the area this is the trend of the predominant folds of the Lower Greensand. Between Ashford and Oxted and west of Dorking the flexuring near the Chalk escarpment follows closely this direction.

Between the Croydon-Redhill valley and Gravesend the predominant flexures of the Chalk dip slope show a close parallelism to the strike of the Chalk here, but in the Chalk dip-slope of the area between the Croydon-Redhill and Mole valleys this type of folding has not been detected.

It is noteworthy that in the area to the south the trend of the faulted Bidborough-Brenchley anticline shows a parallelism to the predominant folds of the Lower Greensand.

In the neighbourhood of London and North Kent the level of the so-called Palaeozoic platform is approximately —1,000 feet O.D. At Richmond it is —1,220 feet O.D., and farther west it sinks to a lower level as proved by the boring at Ottershaw, near Chertsey, which at a depth of 1,583 feet had penetrated to the Lower Greensand only. Borings in connexion with the Kent coalfield between Ashford and Maidstone prove that the southern edge of the Palaeozoic platform is situated north of the Chalk escarpment, and the great thickness of the Mesozoic rocks encountered in the deep borings at Hothfield, Pluckley, Penshurst, and Old Soar, Wrotham (**5**), (**24**), suggest that in this area also the edge of the Palaeozoic platform lies north of the Chalk escarpment.

A comparison of Strahan's map (**6**) showing the form of the Palaeozoic floor on which the Neozoic rocks of the London Basin were deposited with one showing the structural features of the Lower Greensand and Chalk shows a close parallelism of the trend of the southern edge of the Palaeozoic platform with the predominant folds of the Lower Greensand and Chalk. It is therefore natural to suggest a causal relationship between these two sets of features, and the evidence strongly supports the view that the pressure from the south which brought about the elevation of the Wealden Dome raised the edge of the Palaeozoic floor to its present level and threw the more recently consolidated Mesozoic sediments into a series of lateral folds roughly parallel with its southern edge.

The form of the Kent Coalfield (**16**) suggests that the folding of the Mesozoic rocks follows still older lines of folding in the Palaeozoic rocks. In the Boulonnais, where the Palaeozoic rocks are exposed at the surface, this suggestion is capable of proof. In the northern part of the Boulonnais the predominant flexures continue the direction of the predominant folds of the Maidstone-Ashford area, and the effect of faults and folds in the Palaeozoic rocks here on the surrounding Mesozoic rocks can be studied. The Hydrequent fault affords an excellent example. This fault is a reversed fault separating the two synclines of Rinxent and Hardinghen in the Palaeozoic rocks. Farther to the west in the Jurassic rocks it is represented by the Onglevert anticline, whose axis continues the trend of the fault to the coast.

North of Ferques in the neighbourhood of Landrethun the trend of the Chalk escarpment is determined by an extension of the Courte-Dune fault, a fault of post-Cretaceous age which follows closely the direction of an anticlinal axis—the Caffiers anticline—in the underlying Palaeozoic rocks. Farther to the west in the Jurassic rocks, the Caffiers anticlinal axis is represented by an anticline—the Gris Nez anticline—of post-Jurassic age, and a fault—the Courte-Dune fault—of post-Cretaceous age. These are well exposed in the coast at Cape Gris Nez, and Professor Pruvost has suggested the possibility that the folds in the Palaeozoic rocks of the Marquise-Ferques district may be continued to the English coast (**25**, p. 50).

The N.E.–S.W., and S.E.–N.W. Structures.—It has been suggested that folding of the Neozoic rocks of the London Basin on this plan is associated with faults in the underlying Palaeozoic floor (**23**, p. 184). The Stour gap from Wye to Chilham belongs to this set of features, and borings at Chilham and Harmansole indicate a change in the nature of the Palaeozoic platform in the neighbourhood of the Stour gap (**24**). At Ashford the Stour Valley monocline is associated with folds in the Lower Greensand distinct from the predominant strike folds of the area.

Deep borings at Cliffe, Sheerness, Frindsbury, and Chatham indicate that the Cuxton-Sheerness syncline has affected the base of the Gault and is therefore probably related to the N.E.–S.W. structural feature in the Palaeozoic floor. The only extensive flexure in the Lower Greensand belonging to this set of features is the Shode Valley syncline. If the lower Darent valley continues this fold its direction here may have been determined by a structural feature in the Palaeozoic platform, but from a consideration of the Mesozoic sediments known to exist in the Shode valley it is exceedingly unlikely that it represents a feature in the underlying Palaeozoic rocks here. It is noteworthy that it occurs very near the change in direction of the southern edge of the Palaeozoic floor, with which feature it more probably may be related (**27**, p. 49).

The Betchworth fault of N.W.–S.E. trend is better considered with the Mole Valley monocline.

In the Lower Greensand flexures trending N.E.–S.W. are less numerous than those trending N.W.–S.E. Although flexures of N.E.–S.W. strike are well developed in the Palaeozoic rocks of the Boulonnais, they have had far less effect in determining later folding than the flexures trending W.N.W.–E.S.E.

The N.–S. features in the Chalk.—There is little direct evidence that the N.–S. valleys in the Chalk near Dorking, Merstham, and Maidstone are directly related to the form of the underlying Palaeozoic platform, but certain facts are suggestive of a connexion between the two sets of features.

West of the Mole gap borings prove a marked deepening of the Palaeozoic floor, and the valley itself marks the western limit of the Thanet sands.

In every case the continuity of the strike-folding in the Lower Greensand is broken opposite the gaps.

North of the Thames the direction of the Medway syncline is continued by the Billericay disturbance, and the Croydon-Redhill monocline by the Lea Valley monocline, although in each case with opposite downthrow.

The Medway syncline is associated with change of trend of the Palaeozoic platform.

The E.–W. folds in the Chalk cannot be traced west of the Croydon-Redhill valley.

South of the Mole gap is the Arun gap which coincides with a syncline in the Upper Greensand (**2**, p. 278).

VIII. THE AGE OF THE FOLDS.

In all problems involving the age of structural features it is only the period of most pronounced movement to which a definite age can be assigned.

The folding in the Isle of Wight has affected Oligocene beds, and is therefore probably of Miocene age. The major uplift of the Wealden Dome apparently belongs to the same period.

The lateral flexures may have been in existence in pre-Tertiary times. Non-sequences known to exist in the Lower Gault may indicate that lateral folding of the Lower Greensand was in progress during Albian times (**26**, p. 79). There is, however, conclusive evidence of a pre-Tertiary age of some of the folds, and it is in this period that the flexures that produced the major transverse gaps were initiated. In North-west Kent the relation of the Chalk zones to the Well Hill gravel shows that here the E.–W. folding in the Chalk must have been initiated in pre-Tertiary times. It has been indicated that the Mole and Croydon-Redhill gaps mark the western limit of the Thanet Sands and Blackheath beds respectively. These gaps, therefore, represent lines of movement in early Tertiary times. A study of the Chalk zones of the Medway area in relation to the Blackheath outlier at Hollyhill shows that the Medway syncline is in part pre-Tertiary (**20**). Messrs. Gill and Collins have shown from a study of the distribution of the pebbles at Shottenden Hill, near Chilham, that drainage along the line of the present Stour was in existence in Ypresian times, which suggests an early Tertiary age for this fold (**22**, p. 311). A parallel fold, the Blanc Nez anticline, is known to be post-Cretaceous, and may therefore, like these, be an early Tertiary in age.

The Chalk dip slope, especially in Kent, is strongly suggestive of a plain of erosion which must, as Prestwich's diagram shows, be post-Eocene in age (**3**, p. 126), and it is probable that the submergence of the area in Diestian times, and its subsequent uplift, has produced a sloping plain from which the present features have been carved.

The presence of Lower Greensand chert along the Chalk escarpment supports the theory of planation. The view that the transverse gaps owe their origin to marine action in Pliocene times (**13**, p. 47) is a revival of the old theory of the marine origin of the Chalk escarpment, and cannot be supported (**15**). It seems, therefore, that the Vale of Holmesdale must be of post-Diestian age. The coincidence of the rivers with lines of folding indicates the strong probability that the latter must have been in existence before the drainage was initiated, and the uniform level of the presumed Diestian deposits along the escarpment of the North Downs precludes the possibility of extensive movement along the lines of transverse flexure in post-Diestian times (**18**, p. 101).

The topography of the Weald has therefore been controlled by earth movements of a later date than those that have determined the features of the Boulonnais, which, in the main, are of post-Jurassic age, and the courses of its major consequent streams in the area considered have been determined by transverse synclinal or monoclinal folds, whereas the courses of the subsequent streams of the Boulonnais—the Slack, Wimereux, Liane—have been determined largely by faults.

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The Evishanoran Esker,[1] Tyrone.

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A VALUABLE monograph on "The Glacial Geology of the North-West of Ireland" (*Proc. R. Irish Acad.*, xxxvi, 1924, pp. 174–314, pls. 8 and 9) by Professor J. K. Charlesworth describes the complex glacial phenomena of Tyrone. He endorses the main conclusion of my paper on the Irish Eskers (*Phil. Trans. Roy. Soc.*, 1920, vol. 210, pp. 115–51) that they are usually deposited along the margin of a glacier, and are not due to subglacial rivers. The two works further agree in their rejection of the long advocated theory that Irish glaciation was dominated by a huge dome of ice which accumulated as snow above the Central Plain and over-rode the surrounding mountains. That view, due to Hull (*Physic. Geol. and Geogr. Ireland*, 1878, p. 228), has in later years been advocated, amongst others, by Mr. T. Hallissy (*Proc. R. Irish Acad.*, xxxi, part 7, 1914, p. 9), and also by him in association with the late Professor Cole (*Handb. Reg. Geol.*, Ireland, 1924, p. 46; Cole, ibid., British Isles, 1916, p. 328). The lines of ice movement marked on my map (op. cit., 1920, p. 143) illustrating the distribution of the Irish eskers are fundamentally inconsistent with the traditional theory; I am therefore glad to find that theory emphatically rejected by Professor Charlesworth. He adduces convincing evidence that the ice was formed on the mountains and flowed from them on to the plains. In two minor questions Professor Charlesworth differs from the views of my paper. I remarked (op. cit., p. 133) that the eskers of Tyrone are "different in several respects" from those of the Central Plain. I did not state the differences as I mentioned the Tyrone eskers only in reference to the subglacial formation of eskers; and as they gave no support to that process, I briefly referred to them as having had the same marginal origin as the typical eskers of the Central Plain. The differences I had in mind were that the Tyrone eskers occur at higher levels and are independent of the 350 ft. contour ; that their levels are very varied, as the eskers rise up steep hill slopes, as much as 190 ft. in 700 yards, and they show no such limitation as the association of those of the Central Plain with the 300 ft. contour (cf. e.g. sketch map, Irish Eskers, p. 143) ; and that the Tyrone eskers are usually shorter, and some occur in gridlike groups instead of extending in long curving lines with occasional bifurcating branches. The eskers at Creggan, Dunnamore, and Davagh, are single well-defined ridges like those of the Central Plain ; but others, such as the Evishanoran group, are so different that they may belong to a distinct subdivision of eskers.

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[1] The term esker is used as defined *Phil. Trans.*, vol. ccx, 1920, p. 147.

The second point on which Professor Charlesworth dissents is that he considers that I placed the ice connected with the Evishanoran Esker on the wrong side. As that question affects the interpretation of esker evidence, I thought it advisable, before concluding a paper on the corresponding Scottish formations, to revisit Tyrone to see, if Professor Charlesworth were right, which of the criteria to which I had trusted was unreliable. One of the most impressive features in central Tyrone is the glaciated crest of the Sperrin Mountains (2,240 feet) and of the Mullaghbolig-Carnanelly range (1,851 feet), which rise to the north of the broad valley from Omagh to Loch Neagh that Professor Charlesworth has aptly called the Omagh-Draperstown Corridor. As the Sperrin Mountains had been over-ridden by ice from the north-west, it appeared probable that such relatively low hills on the southern side of the Corridor as Evishanoran (886 feet) and its neighbour, Slievemore (842 feet), should have been crossed by the northern ice. Nevertheless, the course of the Evishanoran Esker appeared to indicate movement from the south. The northward movement of the ice in that area had been claimed by Hull (op. cit., 1878, p. 237 and map, opp. p. 211) ; but I regarded the major glaciation of the area as having been from about west or north-west—a direction adopted both by Dr. Dwerryhouse (*Q.J.G.S.*, lxxix, 1923, p. 420) and Professor Charlesworth.[1] The Evishanoran Esker appeared to date from a late stage when the last of the ice, lingering in sheltered positions upon the northern slopes of the hills, flowed down them into a glacial lake.

During my second visit bad weather and mist prevented the preparation of a detailed map showing the irregular inner boundary between the esker drift and the underlying boulder clay ; but the main features in the arrangement of this esker group are shown on the sketch map, Fig. 1.

Evishanoran is 12 miles in a straight line west of Cookstown and 6 miles north-west of Pomeroy.

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[1] Professor Charlesworth regards the movement as from the south-west during the later stages of the glaciation.

I. THE MATERIALS.

The rock which forms a large majority of the pebbles and boulders in the Evishanoran Esker is a coarse quartzose granite with a pinkish-red felspar, and sometimes much biotite or hornblende.

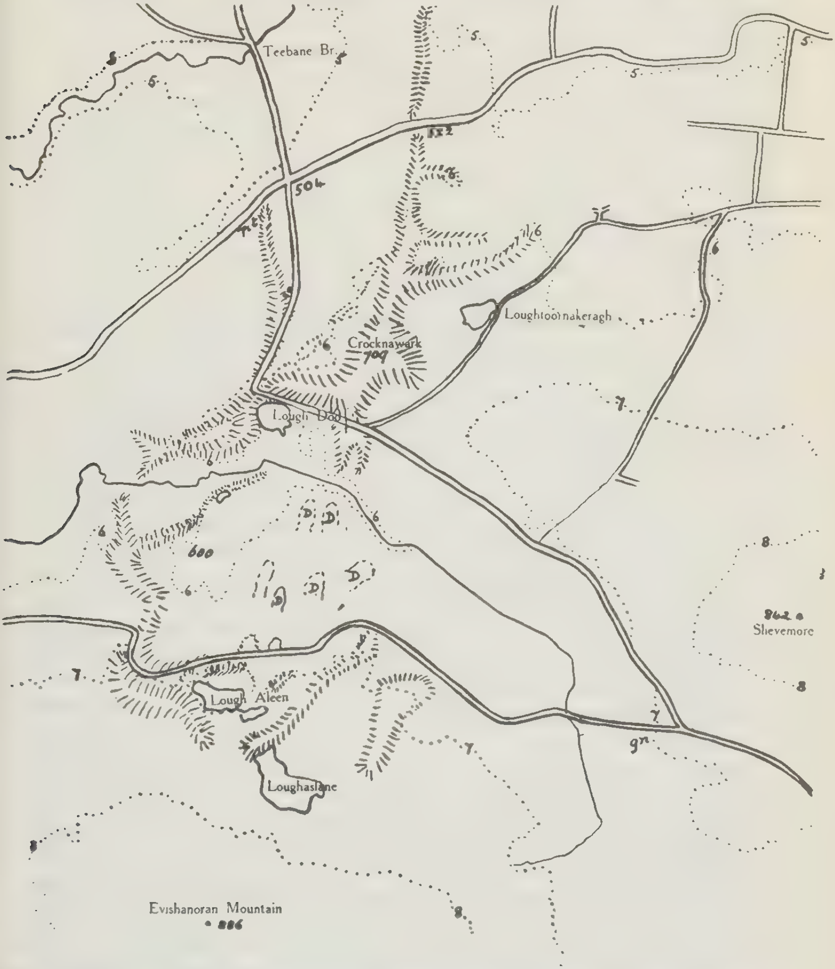

FIG. 1.—Course of the Evishanoran Esker — marked by hill shading. Scale 2·75 inches = 1 mile. 5, 6, 7, 8 mark the 500, 600, 700, and 800 ft. contours. D = Drumlin; gn = gneiss.

The second important constituent is a varied series of representatives of the "Tyrone greenstones". This series includes the compact aphanitic varieties, epidiorite, diorite, greenstone schists, and a gneissose felspathic greenstone which appears to be a hybrid rock between granite and diorite. The pebbles also include a biotite-muscovite gneiss which may be matched exactly, a few yards down the road to Evishnacrancussy from the road from Lough Doo to Pomeroy, at the height of 700 feet and 500 yards south-west from the summit of Slievemore.[1]

The granite with the red felspars is also abundant in the sheet of gravel along the Ballinderry River, south of Dunnamore, but it is scarcer in the esker gravels to the north. Thus it is comparatively scarce at the pit where the road (at 550 feet) from Dunnamore village passes through the esker east of Dungate Rock. A quarter of a mile further north-north-west, in another pit on this esker, I found one 5 inch block of this granite, but no pebbles of it; and further north it is apparently very rare. Occasional specimens also occur in the Creggan Esker, where it crosses the Cookstown road 3 miles west of the Evishanoran Esker.

Some specimens of this granite are rich in hornblende and biotite and have doubtless come from the passage rock into the local syenite and diorite described by Portlock. The granite in the esker agrees in all respects with the Tyrone granite which outcrops in the lower slopes of Slieve Gallion, and along the hills thence south-westward to the north of Pomeroy. This granite has been described by Portlock and Cole (op. cit., 1900, pp. 434–49) and in the Explanation of Sheet 26 of the Geol. Survey of Ireland.[2] Cole suggested (op. cit., p. 431) that in addition to the known occurrences of this granite more might be hidden under the peat. It may occur around the summit of Evishanoran Mountain; the upper part of that mountain is covered with drift and peat, and the stones in the stream beds there are a decomposed granite, which in the size and proportion of the quartz agrees exactly with that of the pink felspathic granite of the esker. The boundary of a large area of granite is marked on the Geological Survey Map (Sheet 34) as passing a mile south of the summit.

The esker material has therefore come from the southward, a movement consistent with Professor Charlesworth's (op. cit., pp. 230, 231) remark that the erratics of the Tyrone granite were carried north-eastward and that no boulders of the Slieve Gallion rocks are found south of their outcrop.

The southern origin of the granite and greenstones in the esker is supported by the absence of any undoubted northern rocks, which are abundant in the drifts further west. Thus in the Creggan Esker, 3 miles to the west, and in the moraines 5 miles still further west, a mile east of Mountfield, there are numerous northern rocks. In the Creggan Esker there are Dalradian quartzites from Donegal, hand specimens of which are indistinguishable from the Schiehallion quartzite of the Highlands, a mica-schist which is identical with that of the Sperrin and Carnanelly Mountains, and other rocks from western or northern sources. The Dalradian quartzite is also common at Brackagh South, 3 miles west of Creggan, in gravels formed by the denudation of the morainic drifts. As the north-western ice may have reached Evishanoran in the early glaciation, some north-western rocks may be found there, but they are apparently very scarce.

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[1] This is the rock described by Cole ("Metamorphic Rocks of Eastern Tyrone," *Trans. R. Irish Acad.*, vol. xxxi, 1900, p. 449).

[2] This granite has been described as Devonian, but it has been shown by Cole (op. cit., p. 432) to be pre-Devonian.

The southern origin of the material is supported by the course of the esker. It includes three chief sections. The uppermost, the Lough Aslane section, lies south of the road through Evishnacrancussy. At its western end on that road its base is at about 700 feet; thence it rises to the ridge south-west of Lough Aleen; it is breached by a stream from Evishanoran and begins again abruptly by a steep rise to 770 feet, and passes as a sinuous ridge to the north-west of Lough Aslane and descends on a curved course to the road at Evishnacrancussy; a branch from Lough Aslane reaches the same road at a little below 700 feet further to the east. A low branch lies between Lough Aleen and the road. This section of the esker lies along the northern foot of the upper part of Evishanoran Mountain, against which the esker gradually ends at about the height of 770 feet.

The second or Lough Doo section begins at the Evishnacrancussy road west of Lough Aleen; thence it extends due north as a steep ridge, which bends to the north-west, and descends steeply to the stream from a tarn west-south-west of Lough Doo. A branch runs east-north-east and ends as a low ridge which passes the northern side of that tarn. The esker rises steeply from the stream and bending to the east and east-north-east forms the high ridge to the south-west and west of Lough Doo; a deep oval kettle-hole depression lies at its northern foot between the esker and the track leading to the bend of the road west of Lough Doo. The esker then bends north and curves round the lough; it is cut through by the road gap and then bends eastward, rising to 709 feet at Crockanawark, to the north-east of Lough Doo; it then turns northward and descends steeply to the Cookstown road at the level of 520 feet. Its course, which is convex to the north-west, indicates that it was formed by some agent that brought its material from the south-east along the depression between Slievemore and Evishanoran Mountain.

The third section of the esker lies along the foot of the second section from Lough Doo to the Cookstown road. It branches off a little below 600 feet north of the lough, and passes behind the farm house and reaches the Cookstown road just west of the Teebane Bridge cross roads at 505 feet.

The esker, both as a whole, and in its subdivisions, is concave to the south-east. Professor Charlesworth (op. cit., p. 252) remarks of the formations at Plumb Bridge that their invariable convexity to the east is proof of a thrust in that direction. This criterion is at least the general rule and is applicable in this case. The alternative would require that, at the formation of the esker, ice from the west or north-west reached Evishanoran in such thickness that it thrust an arm uphill into the valley between Slievemore and Evishanoran.

The formation of the esker on the margin of the ice from the south-east appears consistent with its steep rise up the hillside. The outlets at each end of the Corridor were doubtless closed by glaciers. and its floor was covered by the glacial lake, the complex history of which has been worked out by Professor Charlesworth. The front of the ice would have receded uphill as it melted, while the opening of outlets from the glacial lake would have lowered the water level. Hence the esker would have extended downward to the floor of the basin.

The conclusion as to the course of the esker is further supported by the sharp limitation of the esker drift to the west and north-west, while the ground to the south-east is littered with hillocks of it. The absence of the drift material to the north-west of the esker appears further evidence that it was brought by some agent working from the south-east. The nature of that agent is somewhat uncertain. The three concentric ridges may be kames formed by deposition at intervals in the retreat of the ice ; or they may have been formed by the denudation of a sheet of gravel that had been washed out of the boulder clay ; in that case, they would be pseudo-kames. I was unable to make a sufficiently detailed examination of the bedding in the esker to form a confident opinion on this point.

THE DUNNAMORE-DAVAGH ESKERS.

From the Cookstown-Omagh road where it is crossed by the northern branch of the Evishanoran Esker a narrow esker continues northward across the plain ; it is cut through by the Ballinderry River and continues past Dunnamore smithy, beyond which the road to the north keeps on its sinuous crest for about a mile. The esker there rises from the floor of the valley between Craigard and the Beleevnamore range to the east, and the moors behind Black Rock to the west. The esker in this part of its course is of a sub-morainic type, the boulders being large, irregular, and angular ; the bedding is ill-defined ; there is often but little sand, and though all the material has been water-washed, it is sub-angular and very little water worn. The Dunnamore Esker, after bending to the north-east from the road, gradually ends at the height of about 700 feet near Beleevnabeg, against the broad drift platform at the western foot of the valley between Dunnamore and the Broughderg Bridge ; the mounds become larger as the valley descends towards the north. The most conspicuous is the conical hill just west of Crocknashinna House. There the esker turns to the north-east and is continued as the Davagh Esker (Fig. 2) which can be seen from the road near Black Rock crossing and recrossing the southern branch of the Broughderg River, and curving around the north-western foot of Craiggrena, the north-western spur of Beleevnamore. The Davagh Esker appears to end near the Draperstown road at the height of about 700 feet. As the curve of this esker is concave to Beleevnamore it was apparently formed by ice descending the north-western slopes of that mountain in the last stage of the glaciation.

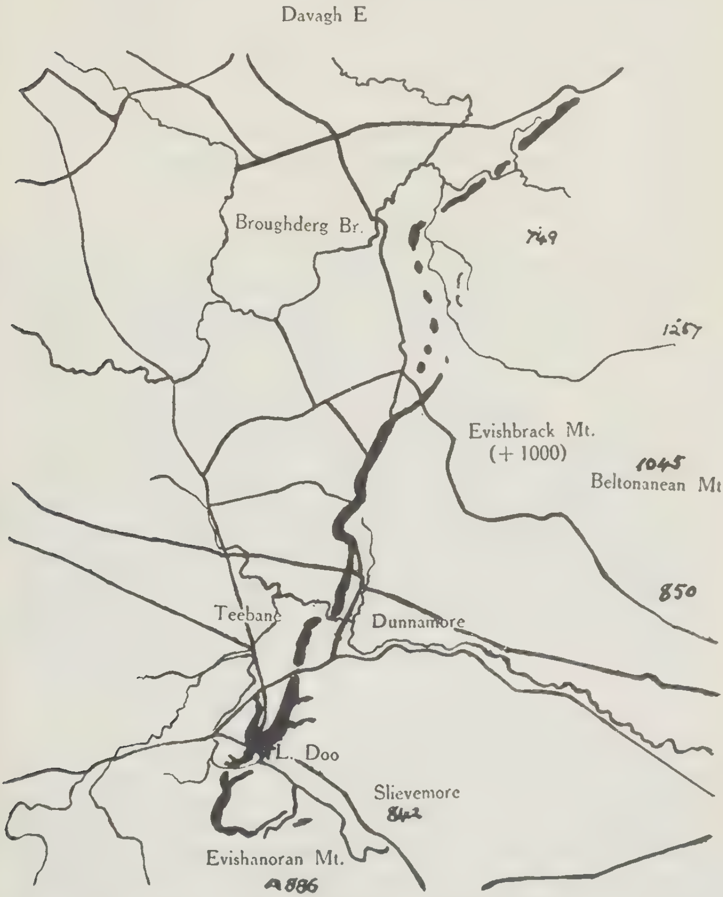

FIG. 2.—The course of the Evishanoran, Dunnamore, and Davagh Eskers; shown in thick black. Scale ·75 inches = 1 mile. Heights in feet.

The southern origin of the constituents of the Evishanoran esker, its steep ascent to the south, the fact that the curves of its course are concave to the south-east, and the litter of esker material on the south and south-eastern side all indicate its formation by an agent working down the northern and north-western slopes of Evishanoran Mountain and Slievemore. The curving course of the Dunnamore and Davagh Eskers around the Beleevnamore range similarly indicate the transport of their material down the western and north-western slopes of that range.

A Note on the Characters of some Crystalline Rocks from the Kukuruku Hills (Nigeria).

By John Parkinson, Sc.D.

THE district here to be briefly described lies about 64 miles S.W. of Lokoja in N. lat. 7° 10′ and E. long. 5°, an area of some 400 square miles. The latest map giving the topography is " Nigeria. Ord. Survey, 1924. Sheet 10. Scale 1 : 500,000 ". It should be noted that several names recorded by the Mineral Survey in 1905 are not the same as those on this map, but the sketch-plan now given is thought to be the best possible under the circumstances. A brief account of the Kukuruku Hills is given in the *Quart. Jour. Geol. Soc.*, vol. liii, 1907, p. 317.

The general character of the country is rolling and undulating, with comparatively long and gentle gradients. The surface soil is thin, the crystalline rocks appearing at frequent intervals along roads, in villages and a few inches below the sand of stream beds. The country contrasts strongly with that of the Oban Hills on the Cameroons frontier, and it is only in the Kukuruku Hills that scenery reminiscent of that to the east is found. For purposes of description the rocks are divided into igneous and sedimentary groups.

I. THE ORTHOGNEISSES.

East of Indogun on the banks of the River Osse excellent exposures are found of a differentiated gneissose series.

A well-banded rather coarse-textured pepper and salt gneiss is the commonest rock, often with folds gnarled and bent. This is traversed (see Fig. 2) by light-coloured veins poor in iron and magnesian minerals and by later pegmatite veins. The last-named rock shows as usual many variations in composition, such as pure segregated quartz passing into pegmatite, which in turn passes into biotite-gneiss, the transition being gradual. In the same manner, such local segregation may concentrate the felspar at one end of a vein, the quartz at the other. Locally, late acid veins, with pegmatite coming in sporadically, traverse the rock in almost every direction, some sharply, others indistinctly marked off from the surrounding rock.

Close by, on the path to Otua, basic segregations are indicative of the imperfect mixing of two magmas. The pegmatites are occasionally tourmaliniferous.

The conspicuous rounded gneiss ridges near the Iporo River south-west of Iduani are also orthogneisses.

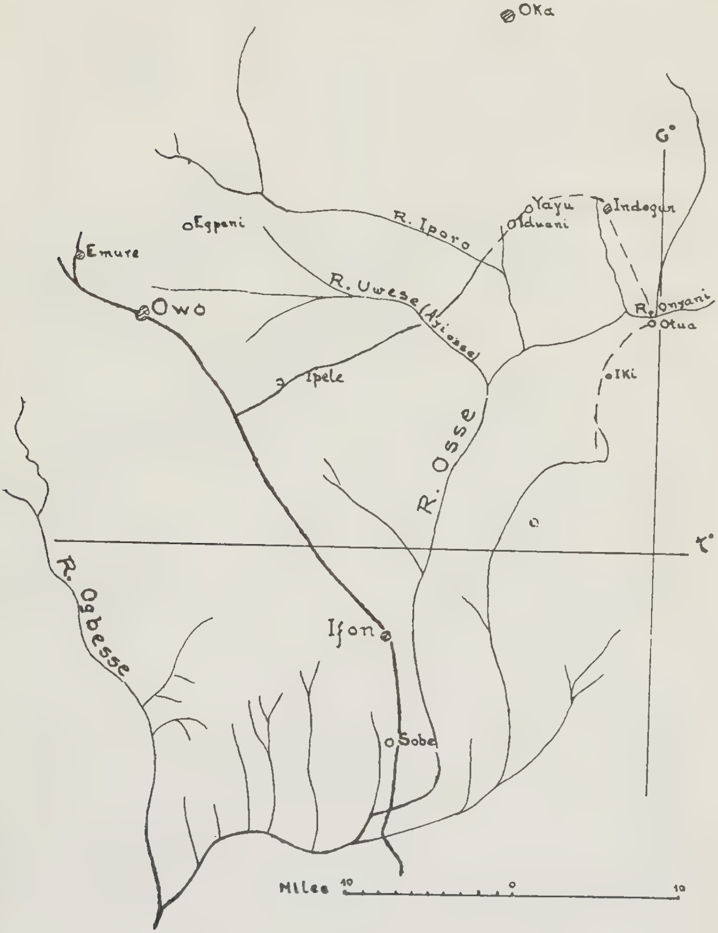

FIG. 1.—Sketch-map of the Kukuruku Hills area, Nigeria.

This rock is not very micaceous, a slightly foliated biotite-gneiss with small garnets, as a whole of uniform texture and not showing the numerous streaks, clots, and evidences of differentiation such as the rocks just noticed exhibit, although traversed by many pegmatite veins and rarer ones of quartz containing occasional crystals of pink orthoclase.

The sudden change from the homogeneous biotite-gneiss forming the turtle-backed hill to the banded, streaky gneiss of the much eroded peneplain below is very noticeable.

On this river evidences of permeation by an acid magma of a more basic, i.e. a micaceous rock with some hornblende, are conspicuous. The former is of fine grain and non-porphyritic, the latter a lustrous schist with abundant black mica, usually evenly disseminated but now and again gathered into laminae or concentrated into coarser grained "eyes". The injections doubtless differed somewhat in age, and frequently no hard and fast line marks off the basic from the acid rock, the latter having as a rule little gneissose structure. Pegmatites appear to be the last stage, preceded, though not commonly, by fine-grained narrow basic dykes.

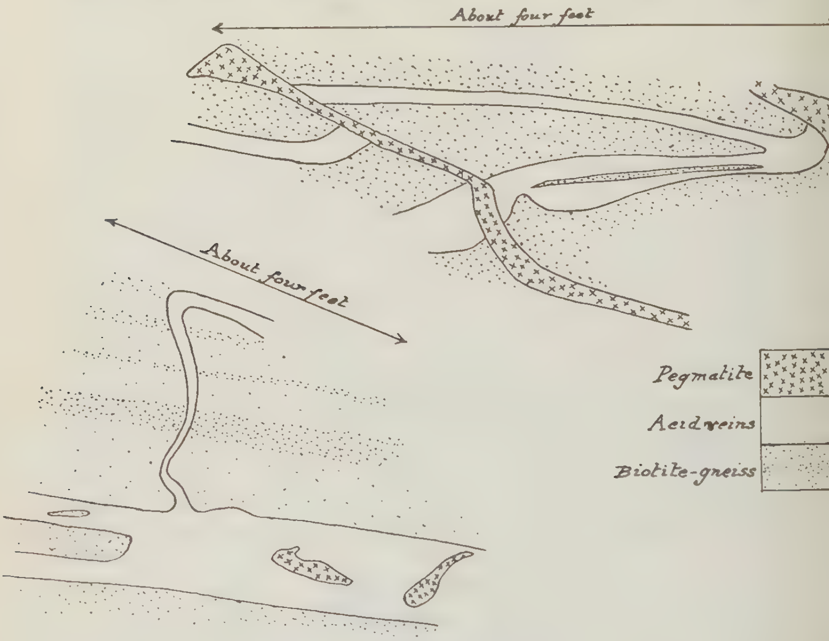

FIG. 2.—Gneiss E. of Indogun.

II. THE PARA-SCHISTS.

The sedimentary part of the series is represented by a quartzite from Otua 1 (there are several Otuas), and is composed of large dusty quartz grains, 5 mm. and upwards not being uncommon, with lobed very irregular outlines and slightly undulose extinction, and small flakes of muscovite.

A little to the north of Otua Hill brown mica replaces the white and is associated with dark green subordinate hornblende. A well-twinned water-clear plagioclase (a rather basic oligoclase), some untwinned felspar, a little microcline and quartz form the remainder of the rock.

A fine-grained microcline-orthogneiss, containing a little yellowish biotite with the usual strong absorption comes from this neighbourhood.

Some of the mica-schists, of which there are many varieties, weather into a violet-red argillaceous material, and as such are common in the district. Near Otua 3 they are greatly crushed. At Ipele they are riddled by quartz veins.

The micaceous schists from the Ayiosse (Uwese of maps) contain both muscovite and biotite, the former being occasionally 10 mm. long and in some slides includes needles of actinolite or sillimanite, the latter being found also in the water-clear or slightly kaolinized felspar, probably albite to medium oligoclase. Quartz is common in some slides and microcline is not infrequent.

This assemblage is most probably the same as the quartz-muscovite-schist and quartz-schist associated with granites, more or less foliated and micaceous gneisses, with muscovite and tourmaline pegmatites and veins of quartz described by Dr. Falconer from Central Kabba and Central Ilorin. The series has an approximately meridional strike. (See *Geology and Geography of Northern Nigeria*, London, 1911, p. 75 et seqq.)

Traverses are given (pp. 65, 66), indicating the various rock types met with some 65 miles north of the Kukuruku Hills, and it is evident that we have here an important group with a wide distribution.

Dr. Falconer concludes that the " place of the phyllites of the Niger Valley to the north is probably taken by the muscovite- and quartz-muscovite-schists ". (p. 83.)

Quartz-mica-schists are also found near Owo and by the incoming of felspar pass into the decomposed bluish or violet-red rock rich in mica already mentioned. At Ipele the rock is poor in quartz, containing weathered felspars and flakes of muscovite, and has passed into a lateritic state.

This schist is associated and alternates with pegmatites containing large red crystals of orthoclase having microperthite and quartz intergrowths, north of the village and on the Ipele-Iduani road. Biotite-schists occur also on the Ayiosse, and by becoming more felspathic pass into biotite-gneisses containing flakes of muscovite. The rocks show signs of crush and are apparently folded with acid veins, the whole cut by pegmatites.

At Iduani the gneisses are very micaceous and much cut by pegmatites, which shade into a rock nearly a granite in structure.

The decomposed mica-schist already referred to occurs also between Iduani and Yayu with quartz-schists and pegmatites.

SUMMARY.

From the foregoing notes it is evident that there exists in this part of the Kukuruku District an igneous series showing the familiar veining, banding, and mingling of rocks of increasingly acid composition, and also a group of completely altered sediments.

The relationships of these two are doubtful, but as quartz[1] veins and pegmatites are integral parts of the igneous series, and as the former are intrusive into the schists and the latter alternate with them in some road sections, the balance of evidence indicates that the schists are the older of the two groups.

Evidence pointing to a similar conclusion is recorded from the neighbourhood of Oloke-meji on the railway south of Ibadan. Quartz schists are here associated with streaky gneisses and traversed by pegmatite veins. The most basic form of gneiss contains sufficient mica to make it greyish-black in colour and it is characterized by red garnets up to 1 inch or so in diameter. The quartz-schist group passes into an alternating quartz-schist—mica-schist series.[2] This appears to be older than the gneiss from the presence of pegmatite veins clearly traversing the schist across its foliation and also from the fact that the latter is more crushed, a wrinkled structure having been produced here and there.

There can be no doubt that the rocks of the Kukuruku Hills are found here also.

In regard to the southern boundary of the crystalline rocks, it is noteworthy that a white felspathic sandstone occurs about 3 miles east of the ford over the Osse River on the path to Ifon from Iki. A streaky banded gneiss is found in the river itself. Outliers of the sandstone probably occur to the north-east of Ifon.

An Analcite-bearing Tuff in the Carboniferous Limestone of Derbyshire.

By H. C. SARGENT, F.G.S.

IN the course of a recent study of the microscopic characters of the pyroclastic rocks of Derbyshire, a colourless, isotropic mineral, with refractive index considerably lower than that of the balsam, was noted in a thin section of a tuff from Cressbrook Dale.

The rock consists essentially of a mass of lapilli containing much yellowish basaltic glass, often partially devitrified, and many felspar laths, sometimes with straight extinction, in a cement partly of calcite, and partly of amorphous, opaque material, white or grey by reflected light, which is probably decomposed volcanic detritus, of the same nature as the "toadstone-clays" of Derbyshire. Vitroclastic structure is abundant.

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[1] At Owo the gneiss is riddled with coarse quartz veins.

[2] For the latest description of this part of Nigeria and an admirable geological map, see R. C. Wilson, *Bull. No. 2 Geol. Surv. of Nigeria*, "The Geology of the Western Railway, Section I."

The lapilli often contain numerous small vesicles, and in the interstices between these a greenish, fibrous mineral with faint pleochroism, moderate birefringence, and positive extension of the fibres, often occurs. In one instance this mineral pseudomorphs a crystal of olivine. It is probably some variety of chrysotile.

It is mainly within the vesicles, where it is often associated with calcite, that the mineral which forms the subject of this paper is seen. Small patches sometimes occur within felspar laths, and occasionally it appears to pseudomorph an entire lath. Faint anomalous birefringence is often shown.

The optical characters left it uncertain whether the mineral was fluor, sodalite, or analcite.

A specific gravity test ruled out fluor. Crushed fragments of the material all floated in bromoform. (Sp. Gr., 2·84.)

Three separate tests, by treating crushed fragments with cold dilute nitric acid to which silver nitrate was added, failed to reveal the presence of chlorine. Sodalite was therefore excluded,[1] as was anticipated from the improbability of its occurrence in these rocks.

Finally, the mineral, when treated with concentrated hydrochloric acid, gelatinized and took a stain from a solution of malachite green. This test appears definitely to prove analcite.

The interest of the occurrence lies in the absence of any previous definite record, so far as I am aware, of zeolites in the igneous rocks of Derbyshire. Farey [2] states that it is " not uncommon " to find " zeolite " (among other minerals) in his " 3rd toadstone " in the neighbourhood of Miller's Dale, but it is difficult to understand to what mineral he refers, and thin sections were, of course, unknown in his day.

The absence of zeolites from these rocks was pointed out in a former paper,[3] and it was suggested that the temperature of final consolidation of a submarine lava-flow was too high to allow of the formation of such low-temperature minerals.[4]

It is obvious that this consideration would not of necessity apply to a tuff, the cooling conditions of which might be very different from those of a lava-flow.

The localities from which the specimens were obtained are the bed of the stream and an exposure alongside the cart-track, both of them on the north side of Ravensdale Cottages, Cressbrook Dale.

I have to acknowledge the kindness of Dr. Greenly in examining one of the thin sections. He confirmed my determination.

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[1] Cf. A. Holmes, " Petrographic Methods and Calculations," 1921, p. 279.

[2] " General View of the Agriculture and Minerals of Derbyshire," vol. i, 1815 (reprint), p. 443.

[3] H. C. Sargent, " On a Spilitic Facies of Lower Carboniferous Lava-flows in Derbyshire," *Quart. Jour. Geol. Soc.*, vol. lxxiii, 1918, p. 21.

[4] See F. W. Clarke, " The Data of Geochemistry," *Bull. U.S. Geol. Surv.*, No. 616, 3rd ed., 1916, pp. 369 and 416.

The Old Red Sandstone and Avonian Succession at Westbury-on-Trym.

By S. H. Reynolds, M.A., Sc.D., and Stanley Smith, M.A., D.Sc.

(PLATE XX.)

I. Introduction.
II. Description of the Succession.
III. Faunal List.
IV. Conclusion.

I. Introduction.

In the erection of a new home of rest—St. Monica's, in the grounds of what was formerly Cote House, near the top of Westbury Hill, an interesting section[1] of the upper part of the Old Red Sandstone and of the lower Avonian rocks up to the top of Z_1 was exposed in digging the foundations. Although the section lies only a little over a mile north-east of the Avon section and the general succession of the two is very similar, the Westbury section is of considerable interest, particularly as certain levels were well seen which are not exposed in the Avon section. In all the following tables the strata are described from below upwards.

II. Description of the Succession.

The Old Red Sandstone.[2]

These rocks were exposed in the lower part of a new quarry opened at the northern end of the grounds. This quarry yielded the principal stone used in the buildings. The Old Red Sandstone seen comprised the following beds (see Fig. 1a):—

	ft.	in.
1. Hard red sandstone with subordinate shale to base of section	20	0 seen.
2. Flaggy sandstone with red and green shale	2	0
3. Hard red sandstone	5	6
4. Flaggy sandstone with red and green shale	2	0
5. Hard red sandstone with shale band, 5 in. in middle	1	2
6. Thin bedded hard sandstone passing into shale	1	0
7. Soft deep green shale		8
8. Green and red shale with thin bands of hard sandstone	1	10
9. Hard greenish sandstone with shaly parting	1	4
10. Deep red shale with strong jointing		10
Total thickness exposed	36	4

Notes on the Old Red Sandstone.—The rocks show a close general similarity to those of the Avon Section. As in the other local sections of the Old Red Sandstone, fossils are very scarce, but fish scales, chiefly of *Holoptychius nobilissimus,* occurred abundantly in a conglomeratic sandstone about 30 feet below the top of the series. *Holoptychius* has been found in a very similar position at Portishead.

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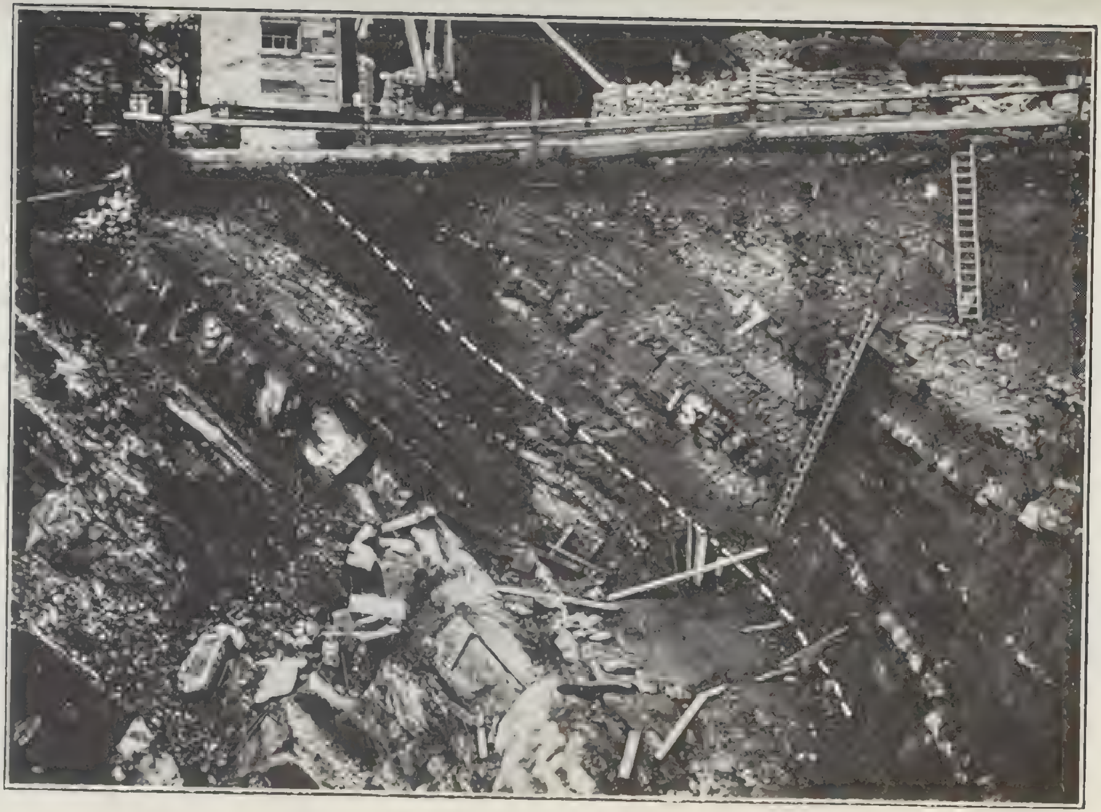
[1] Our attention was first drawn to this section by Mr. C. Carus-Wilson, F.G.S., to whom we are further indebted for some excellent specimens.

[2] Since the MS. of our paper was sent in a description of the Old Red Sandstone section, by Dr. F. S. Wallis, has been published in the *Proc. Bristol Nat. Soc.*, ser. iv, vol. vi, 1924, pp. 179–82.



QUARRY IN THE OLD RED SANDSTONE AND KM BEDS, ST. MONICA'S HOME, WESTBURY-ON-TRYM.
Dotted line marks base of Km beds. For the numbers 3, 15, 17, see table of strata in text.

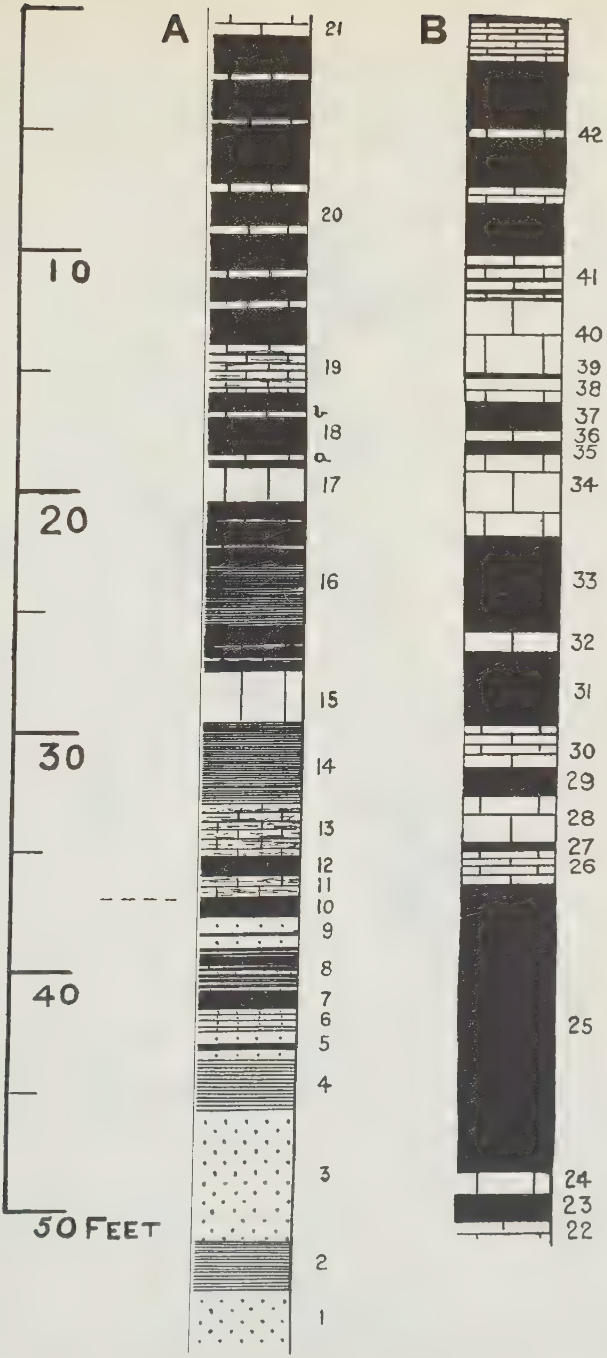


FIG. 1.—Vertical section of the Km beds. A, those exposed in the quarry; B, those exposed in the laundry excavation.

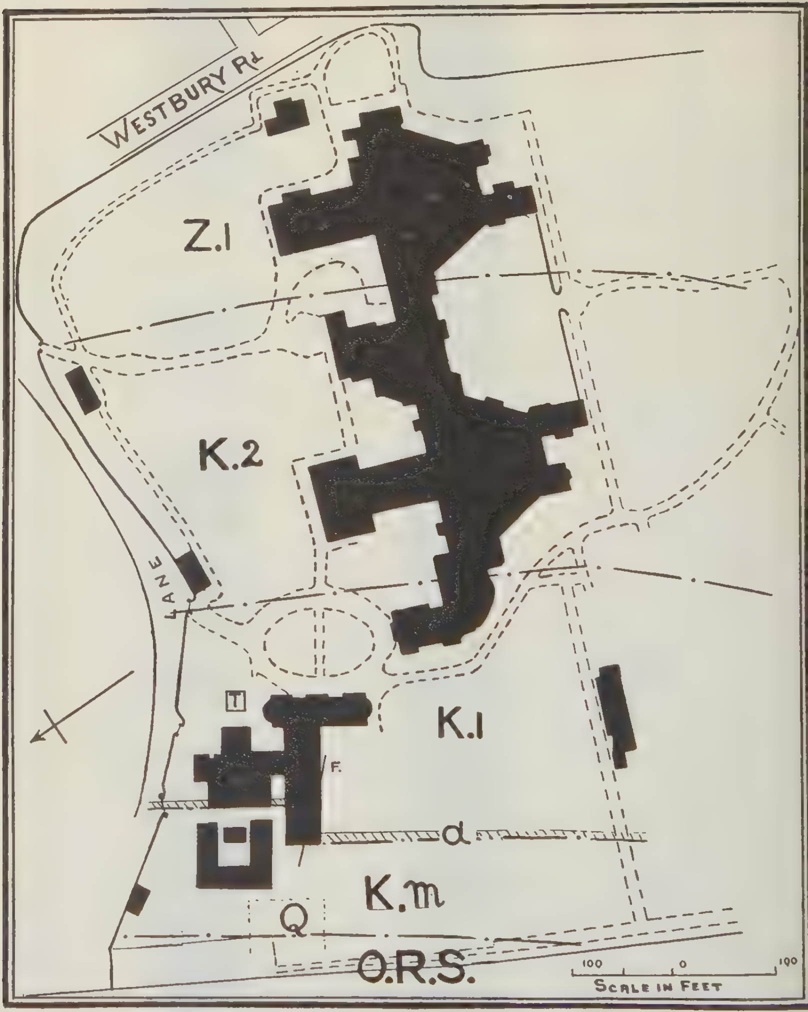


FIG. 2.—Plan of the grounds, St. Monica's Home, Westbury-on-Trym. Q = quarry; T = water tank; F = fault.

There is some evidence of disturbance near the top of the series in the slight overthrusting and the partial squeezing out of some of the shale bands.

The Cleistopora or K beds.

Band 10 in the preceding section is succeeded by a thick series of shales with subordinate limestones, and the base of this shaly series may conveniently be taken as the base of the Carboniferous. The sequence in the lower part of the Km is as follows :—

		ft.	in.
11.	Sandy shale with decalcified limestone		10
12.	Red shale		9
13.	Thin-bedded decalcified sandy limestone	2	2
14.	Hard well-jointed sandy shale	3	3
15.	Massive somewhat sandy limestone algal in parts, few fossils	2	5 (max.)
16.	Shaly band divisible into :—		
	(*a*) Shale with decalcified limestone	7	0
	(*b*) Hard green or red sandy shale, well jointed, deeply iron-stained at joints (similar to bed 14)		
	(*c*) Shale with decalcified limestone		
17.	Algal limestone	1	4
18.	Shale with bands of more or less decalcified algal limestone	3	0
19.	Thin-bedded argillaceous limestone with shale	2	0
20.	Shale with several bands of more or less decalcified algal limestone	11	0
21.	Crystalline limestone with traces of fossils	1	0 seen.
		34	9

The strata detailed above were all seen in the upper part of the Old Red Sandstone quarry and are shown in Pl. XX. A gap of not more than 4 feet separates this section from the section of upper Km, which was exposed in the foundations of the laundry and is shown in Fig. 1B. The succession is :—

		ft.	in.
22.	Compact limestone	3	0 seen.
23.	Shale	1	0
24.	Limestone compact, fossiliferous	1	0
25.	Greenish shale	12	0
26.	Compact unfossiliferous, thin-bedded limestone	1	7
27.	Shale		6
28.	Massive limestone	2	0
29.	Greenish shale	1	2
30.	Thin-bedded unfossiliferous limestone with green partings	1	9
31.	Shale	3	0
32.	Red limestone of *a* type somewhat thin-bedded		10
33.	Shale	4	0
34.	Massive limestone with ostracods	3	6
35.	Shale		6
36.	Compact limestone crowded with ill-preserved fossils, including *Camarotoechia mitcheldeanensis, Cleiothyris roissyi*		6
37.	Shale	1	2
38.	Weathered limestone	1	0
39.	Shale		3
40.	Massive limestone	3	0
41.	Thinly-bedded limestone with shale	2	0
42.	Shale with bands of limestone	10	0
		70	9
	Total thickness of Km beds	105	6

Notes on the Km beds (lowest Cleistopora beds). This fine section bears a general resemblance to that of the Avon, but it is not possible to correlate the two, band by band. The most interesting levels are the limestone bands, those from the lower part being frequently algal and sometimes showing penecontemporaneous brecciation followed by the rounding by solution of the resulting fragments. A few notes on some of these bands are appended.

Band 17 is crowded with *Spongiostroma*, some *Mitcheldeania* being also present.

Band 18.—The lower layer of Limestone 18 (*a*) contains *Ortonella*, the upper 18 (*b*) *Ortonella* associated with *Spongiostroma* and ostracods.

Band 19 is a very fossiliferous layer. Ostracods abound throughout. *Mitcheldeania* is common in the lowest bed, while higher up is a band with Spirorbids, small gastropods and *Modiola*-like lamellibranchs.

In the occurrence of penecontemporaneous brecciation and in the abundance of calcareous algæ, ostracods and Spirorbids, the section agrees with that of the Avon.

In the upper part of Km seen in the laundry excavation, the limestone bands are thicker than in the lower part. The sandy or argillaceous algal limestones are in the main replaced by more massive limestone, sometimes crystalline. Band 11 is a red crystalline limestone of the *a* or Bryozoa bed type. The whole of Km illustrates, like the similar succession in the Avon Gorge, a series accumulated under lagoon-phase conditions (Dixon).

Horizon a (Bryozoa bed).

The Bryozoa bed was fully exposed in a trench and is 25 feet in thickness. The Westbury rock exactly resembles that of the Avon section, varying as does that rock in coarseness and in the extent to which it is impregnated with haematite. As in the Avon rock, some of the bryozoa have their cavities filled with haematite, and some of the crinoids have their structure picked out in the same material.

K_1.

The "palate" bed of the Avon section was not found, the Bryozoa bed being succeeded by 2 feet of soft red and green shale and then by a series of thinly-bedded dark-coloured compact limestone interbedded with green shale, of which about 15 feet were exposed. Of the lower part of K_1, no continuous section was exposed, but some limestone thrown out just east of the boiler-house came from low down in K_1 and contained *Productus bassus* Vaughan and abundant "*Orthotetes*" cf. *crenistria* mut. K (Vaughan), also *Camarotoechia mitcheldeanensis* and *Syringothyris* sp. From a slightly higher level variable limestone including a red crystalline limestone of (*a*) type was thrown out. Here *Chonetes stoddarti* Vaughan and *Productus bassus* were common, and *Rhipidomella michelini* and *Pustula* *subpustulosa* occurred, as well as the gastropods *Euomphalus* and *Bellerophon*, while teeth of *Psammodus rugosus* and *Psephodus* were found in the red limestone of *a* type.

A very fine section of middle and upper K_1 was exposed in the excavation for the water-tank. The details of this section are given as this horizon is entirely unexposed in the Avon section, in fact, there is no good section of these beds to be seen anywhere in the Bristol district. The section is as follows :—

	ft.	in.
1. Compact limestone to base of section. . . .		4
2. Shale		1
3. Crystalline limestone	1	9
4. Shale with limestone bands		10
5. Crystalline limestone, highly crinoidal, sometimes weathering red (cf. Bryozoa bed)		8
6. Compact limestone		10
7. Shale	1	3
8. Argillaceous limestone in several thin bands . .	1	2
9. Clay with lenticular masses of limestone . . .	1	9
10. Compact fossiliferous limestone	1	0
11. Shale		7
12. Compact crystalline fossiliferous limestone . .		4
13. Thick shale (weathering into clay) with two impersistent limestone bands	5	6
14. Shale with band of fossiliferous limestone . . .	2	0
15. Limestone in 5 bands with shaly partings . . .	2	8
16. Shale and argillaceous limestone	1	8
17. Grey crystalline limestone		10
18. Shale or clay	3	2
19. Limestone massive in part, with a little shale . .	7	0
20. Shale		7
21. Crystalline fossiliferous limestone	3	0
22. Compact unfossiliferous rather thin-bedded argillaceous limestone	2	6
23. Calcareous shale	1	10
24. Compact unfossiliferous, thin-bedded argillaceous limestone with some shale	1	2
25. Limestone rather massive and crystalline . . .	2	0
26. Shale		5
27. Limestone rather massive and crystalline . . .	2	0 seen
	46	10

Comparatively few fossils were found in this section, but a great many in smaller excavations on the same horizon. In the lowest beds (1*a*) *Camarotoechia mitcheldeanensis*, *Productus bassus*, *Productus* cf. *martini* (Vaughan), *Rhipidomella michelini*, *Spirifer tornacensis* de Kon., *Orbiculoidea mitidā* occurred. At a slightly higher level *Spirifer tornacensis* became very common. "*Orthotetes*" cf. *crenistria* was abundant throughout. Throughout the *Cleistopora* beds the shale bands when weathered are more accurately described by the term clay.

K_2

Several excavations exposing parts of upper K_2 were made in the course of the work, but lower K_2 was not well seen. The succession is :

1. Shale, with thin bands of compact argillaceous limestone fossils inconspicuous except small crinoids, ostracods and bryozoa. Above comes	about 40 feet seen
2. Thin-bedded highly fossiliferous limestone alternating with shale. *Cleistopora* is common in these beds associated with the characteristic K_2 brachiopods .	60 feet seen

Notes on K_2.—Weathering of the upper beds of band 2 tends to give rise to a thick mass of clay and in a shallow excavation it might be thought that the whole consisted of clay.

According to the subdivisions adopted here, the K_2 is thinner and K_1 thicker than in the Avon Section. "*Spiriferina octoplicata* Sow." was not met with, but several trilobites were found. Bedding planes covered with *Rhabdomeson* and *Fenestella* occurred just as in the Avon section.

Zaphrentis Zone.

β *and* Z_1.

The succession is :—

	ft.	in.
1. Massive dark very fossiliferous limestone . . .	85	0
2. Dark limestone with bands of pale chert . . .	10	0
3. Compact dolomitized limestone, few fossils, the lower beds tending to weather into rubbly rottenstone .	58	0

Notes on Z_1.—In the lowest part of (1) *Spirifer tornacensis* occurs in great abundance in association with *Cleiothyris roissyi*. In this respect the horizon agrees with β of the Avon section. Large "*Orthotetes*" are exceptionally abundant in the overlying strata. A certain amount of chert is met with in Z_1, as in the Avon section, but apparently the level in the Westbury section is slightly higher than in the Avon section. Silicification of fossils is common in both sections.

The Westbury section is in agreement with nearly all the others in the district in the extremely fossiliferous character of lower Z_1, *Leptaena analoga*, "*Orthotetes*" cf. *crenistria*, *Spirifer tornacensis*, *Chonetes* cf. *hardrensis* occurring in great numbers.

III. Faunal List.

The following faunal list has been compiled from the fossils collected for the most part from the actual excavations or from the material dug out of these and lying at the sides of the trench. Most of the Z_1 fossils were, it is true, collected from a large heap, but the association of forms, the lithological character of the material and the position of the heap in the hospital grounds admitted no doubt concerning the horizon of the specimens collected from it ; moreover, the horizon of these was in almost every case confirmed by finding the species in situ.

The following symbols are employed to denote the numerical proportion of the species recorded : * very numerous ; = numerous at one horizon only ; - common ; . single specimen or few specimens only collected ; *m* maximum.

	Km	K_1	K_2	Z_1
Cleistopora geometrica Edwards & Haime			*	.
Zaphrentis delanouii Edwards & Haime				*
Amplexus sp., small form				.
Spirorbis sp.	=			
Orbiculoidea nitida (Phill.)	.	.		
Rhipidomella michelini (l'Eveillé)	–	*	–	
Leptaena analoga (Phill.)			–	*
Productus [*Avonia*] *bassus* Vaughan		*		
,, sp. nov. = *Prod.* cf. *martini* Sow., Vaughan		–	*	.
,, [*Pustula*] *subpustulosus* Thomas		–	–	
,, [*Buxtonia*] sp. nr. *Prod. scabriculus* (Mart.)				.
Chonetes cf. *hardrensis* (Phill.)		*	**m*	*
,, *failandensis* S. Smith			=	
,, *stoddarti* Vaughan		=		
Orthotetes (*Schellwienella*) cf. *crenistria* (Phill.)		*	*	**m*
Camarotoechia mitcheldeanensis Vaughan	.	*	*	*
[? *Eumetria*] sp.		=		
Cliothyris roissyi (l'Eveillé)	.	*	*	**m*
Reticularia lineata (Martin)	.	–	–	–
Spirifer tornacensis de Koninck and vars. (= Sp. *clathratus* M'Coy, Vaughan)		*	*	**m*
Spirifer sp. (? cf. *ventricosus* de Kon.)		.		
Spiriferina octoplicata (J. de C. Sowerby)				.
Syringothyris sp.		–	–	
,, *cuspidata* mut. *cyrtorhyncha* North				*
Modiola spp.	–	.		
Myalina sp.			.	
Parallelodon bistriatus (Portlock)		.		
? *Pterinopecten* sp.				.
Platyceras neritoides (Phill.)				.
Naticopsis sp.		.		
,, ,,	.			
Euomphalus pentangulatus Sow.		–	–	*
Bellerophon sp., small form		–		
Orthoceras sp.		.		
Dichocrinus sp. cf. *D. radiatus* (Münster) and *D. elongatus* (Phill.)				.
Platycrinus sp.				.
Phillipsia truncatula (Phill.)				.
Griffithides globiceps (Phill.)			.	
,, sp.			.	
Ostracods	–		–	
Psammodus rugosus Agassiz		.		
Psephodus sp.		.		
Heterotrypa sp.			–	
Rhabdomeson sp.			–	
Fenestella sp.			–	–
Mitcheldeania sp.	=			
Spongiostroma sp.	=			
Ortonella sp.	.			

NOTES.

Corals.

The forms collected call for no special notice beyond recording the large number of *Cleistopora* obtained and mentioning the fact that a solitary specimen of *Dibunophyllum* was picked up on one of the heaps.

Cleistopora geometrica Edws. & Haime.—About twenty specimens were collected, all from K_2, except one or two which from their associations may have come from β or Z_1; these were found on the large heap of Z_1 material previously alluded to.

Dibunophyllum sp.—Although the occurrence of this specimen can be regarded as adventitious, no other fossils of suspected extraneous source were found. It was associated with typical K_2–Z_1 forms, and no beds of Viséan Stage outcrop anywhere in the neighbourhood.

Brachiopods.

The fossils found in these beds belonged mainly to this phylum, and the species most abundantly represented were *Camarotoechia micheldeanensis*, *Chonetes* cf. *hardrensis*, "*Orthotetes*" *crenistria*, *Rhipidomella michelini*, *Spirifer tornacensis*, and *Syringothyris* spp. Certain forms, *Chonetes stoddarti*, *Ch. failandensis*, *Eumetria* ? sp., occurred in great numbers, but at one very limited horizon only.

Orbiculoidea nitida (Phillips).—Only two specimens were found, one of these being from the lowest limestone band (excluding the algal and ostracod limestones) in the series, bed 21 in Fig. 1A.

? *Eumetria* sp.—The species doubtfully recorded under this generic name is a small shell (about 7·5 × 5 mm.) closely resembling *Retzia carbonaria* Davidson in size and form but differing from Davidson's description and figures[1] in being smooth with very faint longitudinal striae and a few strong concentric growth lines, and in the dorsal valve being flatter and rounder. Davidson founded the species upon specimens from the "Lower Limestone Shales" of Skrinkle, Pembrokeshire, and recorded the species from the same horizon, "close to the Black Rock Quarry," Bristol.

The form described by Vaughan, 1906,[2] agrees more closely with Davidson's species than do our specimens.

Chonetes spp.—Notes on the small species of this genus collected at Westbury and in other localities in the Bristol area have been separately published by one of us.[3]

Spirifer tornacensis de Kon.[4]—All the Spirifers with the possible exception of a single specimen belong to this species. The shells range from slightly to extremely transverse forms, but are mainly intermediate in this respect.

Syringothyris spp.—*Syringothyris* ranges through K and Z_1; the specimens, except in the Z beds, were not sufficiently well-preserved to justify specific allocation.

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[1] *Brit. Carb. Brach. Pal. Soc.*, pp. 219 and 282, pl. li, fig. 3, and pl. Sup., pl. xxx, fig. 16.

[2] *Proc. Bristol Nat. Soc.*, 4th Series, vol. i, p. 163.

[3] GEOL. MAG., 1925, pp. 85–88.

[4] See Vaughan, *Q.J.G.S.* lxxi, 1915, p. 41.

Mollusca.

This phylum was not well represented. A small fragment of a bed, in which *Modiola* sp. occurred in unusually large numbers, was obtained from the Km horizon by Mr. Carus-Wilson. No gasteropod species were common except *Euomphalus pentangulatus*, and, at one horizon only, *Bellerophon* sp.

Trilobites.

Phillipsia truncatula (Phillips) was represented by an unusually large and well preserved pygidium measuring nearly 3 cm. in width and 2·5 cm. in length.

IV. CONCLUSION.

The chief interest of the Westbury succession lies in the fact that good sections were seen of parts of the K beds which are not well exposed in the Avon section or elsewhere in the Bristol area.

We wish to express our sincere thanks to Dr. F. A. Bather for naming our Crinoids ; to Miss H. M. Muir Wood for assisting in determining the Productids ; and to Dr. F. J. North for confirming our determination of the Syringothyrids. We also wish to thank Messrs. Oatley & Lawrence, the architects, and Mr. J. Harlow, the works superintendent, for granting us all facilities for examining the sections.

The cost of the work and publication has been in part defrayed by a grant from the University of Bristol Colston Society.

REVIEWS.

GRUNDFRAGEN DER VERGLEICHENDEN TEKTONIK. By H. STILLE. pp. vii + 443, with 14 text-figures. Berlin: Borntraeger, 1924.

AMONG the great number of works on tectonic geology that have appeared during the last few years in various European countries, the writings of Dr. Hans Stille, of Göttingen, have held a high place. In the present volume we have in a convenient form a summary of his views, which have hitherto been somewhat scattered in publications not always easily accessible to English-speaking readers. As shown in his small work " Die Schrumpfung der Erde ", a reprint of a special lecture delivered at Göttingen in 1922 and already reviewed in these pages, Dr. Stille is to a considerable extent an adherent of the old theory of crust-contraction, a theory which of late has been scoffed at by many geologists: it is clear, however, that by no means the last word has been said on this subject.

In the first place Dr. Stille draws a very clear line of distinction between orogenesis and epeirogenesis. Orogenesis he defines as those types of crust-disturbance which give rise to a distinct alteration in the texture and structures of the area affected, meaning thereby the production of close folding, fracture, both radial and tangential, and cleavage. Epeirogenesis on the other hand, includes those great but simple movements, upward or downward, which affect great areas of the earth, giving rise to continental uplifts and oceanic depressions, but not leading to any modification in detail of the geological structure. The author attacks boldly the conceptions of Suess with regard to the nature of these movements and maintains the occurrence of both upward and downward displacements of the crust in an absolute sense. Incidentally it may be remarked that very little importance is attributed to isostatic processes.

To most geologists, however, the most interesting part of the book will be the first and larger section that deals with mountain-building, from the stratigraphical, rather than from the dynamical, standpoint. Here we have a summary, lucidly set forth, of most of the known facts concerning periods of mountain-building and its reverse in Cambrian and later times. Perhaps wisely, the author does not discuss the events of Pre-Cambrian time. Possible omissions of reference to recent work are apologized for on the ground of the difficulty of obtaining foreign literature in Germany of late years, a plea which is doubtless justified.

It is shown in the course of the discussion how Europe has been built up by successive accretions of folded areas, Caledonides, Variscides, and Alpides, from north to south, as long ago pointed out by Bertrand. An interesting map shows the tectonic subdivisions of Europe, with the dominant trend-lines. Palaeo-Europe, the area of the Caledonides, comprises the British Isles, half of Scandinavia as far as the great south-east thrust, and a long narrow tongue extending into Poland. Thus primitive Europe (Ur-Europa) is divided into two blocks, Eria in the north-west, and Fenno-Sarmatia (roughly, Sweden, Finland, and Russia). Meso-Europe is the region of Armorican-Variscan earth-movement, and Neo-Europe, the area of the Alpine folding, needs no explanation. It may be noted, however, that the trend-lines adopted for this region are more or less of a compromise between those of Suess and of Kober. The relations of the Apennines, southern Alps, and Dinarides are given as expounded by the last named, but the line Atlas-Betic Cordillera-Balearic Isles-Pyrenees is retained, with the backward bend at the Straits of Gibraltar.

It is, however, when we come to the detailed consideration of the evidence for orogenesis in the stratigraphical sequences that this book affords most food for thought. The subdivisions adopted, the minor phases, of each of the great periods above-mentioned are so numerous, and the evidence given for each so detailed, that the impression left on the mind of the reader is that mountain-building has been going on nearly all the time. Thus no less than thirty minor phases of folding are enumerated since the beginning of the Cambrian. In this country, for example, we are accustomed to regard the Mesozoic on the whole as a period of quiescence: but it is beginning to be apparent that this appearance of quiescence is deceptive. We need go no further than Holland and north-west Germany to find that much was happening in Jurassic and Cretaceous times, as set forth in the writings of van Waterschoot van der Gracht and of Stille himself, besides many others. The investigation of the buried coalfields of the Campine and of Dutch Limburg and of the German salt-domes has revealed many things little suspected in Britain, where only a feeble echo of the Kimmerian-Saxonian disturbances is to be traced; probably, however, in the future it will be recognized that these explain many obscure features of British Mesozoic stratigraphy and have an important bearing also on our buried coalfields. It is a far cry from the Dobrudsha to the Market Weighton axis, but there is possibly a connexion, and the key perhaps lies in the Teutoburger Wald.

The discussions in this book, though mainly concerned with Europe, are by no means confined to that continent. A sketch is given of corresponding events in most of the other quarters of the globe, and much attention is paid to recent American work. It may be noted that in America a similar tendency is to be seen to the multiplication of minor phases of orogenesis, as expounded by Schuchert, Blackwelder, and others. In face of all this, if finally established, it seems difficult to maintain Joly's idea of the definite and clear-cut periodicity of periods of revolution, alternating at intervals with periods of quiescence and accumulation of latent heat and potential energy of radioactive origin. The overlap appears to be so great that the argument loses some of its force. However, the settlement of this question is a matter for the future: it is doubtful whether stratigraphical detail is as yet an adequate foundation for the great superstructure that has been raised on it.

R. H. R.

GESTALTUNGSGESCHICHTE DER ERDE. By L. KOBER. pp. vii + 200, with 58 figures, and a folding table. Berlin: Borntraeger, 1925.

IN this book Professor Kober gives a brief and readable sketch of the historical development and present position of tectonic geology, using the term in its widest sense. The first chapter of 16 pages summarizes the growth of the subject from the earliest times down to the publication of *Das Antlitz der Erde*. After briefly passing in review the ideas of classical and mediaeval times, with the usual remarks on the blighting effect of the Church on science, the author concludes that the real originator of tectonic geology was Nicholas Steno. Needless to say, like all other such writers, he omits to mention that Steno was a Catholic bishop. A good summary is given of the "heroic" age of geology, and full credit is paid to Lyell for his share in the inauguration of modern views.

The second chapter deals pretty fully with the history of the contest between catastrophism and uniformitarianism, which the author calls "Aktualismus". The guiding principles in the history ot the earth are considered to be evolution and revolution. These are high-sounding and effective words, but it is as well to pause and consider for a moment what they really imply. Evolution, if understood in the sense of a purely mechanistic law of development, has not much meaning as applied to inorganic materials. There is no inherent reason, so far as one can see, why a purely physical system should change from the less to the more complex; in fact, quite the reverse. The end of all things must eventually be a kind of equilibrium, a uniform distribution of energy without possibility of further change. This is by no means evolution in the biological sense.

Most recent writers on geology have given great prominence to the conception of periods of revolution in earth-history. Now in the last analysis it is difficult to see how this differs essentially from the old catastrophic doctrine of 100 years ago, at any rate so far as regards the physical side of it. As might have been expected, geology seems to be going round in a circle. The orogenic phases of recent writers and the revolutions of Joly would have delighted the hearts of Cuvier and Buckland.

The third chapter deals with earth-history as a sequence of events, contrasting periods of mountain-building and unrest with those of quiescence. Much stress is laid on the doctrine of geosynclinals, the " Orogen ", the mobile belts, in contradistinction to the stable continental blocks. During the whole of earth-history the continents have grown at the expense of the geosynclinals. Naturally much stress is laid on the bilateral character of mountain-chains, and in order to bring this out the conception of geosynclinals is much enlarged. Thus, to take a concrete example, the Carpathians, overthrust to the north, are regarded as the northern wing of the Alpine geosynclinal, while the Dinarides are the southern wing overfolded to the south. Thus the great Hungarian plain becomes the central area of the chain, the " Zwischengebirge ", a word for which a good English equivalent is still to be found. In the Swiss Alps the two wings approach one another very closely, and the Zwischengebirge, the " Narbe " of Suess, is almost suppressed.

In this book, as in many other recent writings on similar lines, little importance is attributed to epeirogenic forces. These give rise mainly to block-movements, mainly characterized by simple fracture, with relative displacement, partly vertical partly horizontal, without definite folding. Such displacements may give rise locally to block-mountains (Schollengebirge), and such are in point of fact of considerable importance in the detailed structure of north-western Europe, among other areas. It is necessary to distinguish carefully between movements of orogenic type, which fold the rocks at the same time as they displace them, and such block-movements which merely shift rock-masses that may or may not have been folded at an earlier date.

The fourth chapter, of nearly a hundred pages, gives a systematic description of the tectonics of earth-structure on a geographical basis, while the fifth and last deals with generalizations and theories, including a discussion of the tectonics of igneous activity. The author holds that orogenesis gives rise to Pacific vulcanicity, thalattogenesis to areal vulcanicity (fissure eruptions), while epeirogenesis is accompanied by Atlantic vulcanicity.

In his general discussion of the underlying causes of earth-movement, Professor Kober attributes to the contraction of the earth as a whole a degree of importance not usually assigned to it in recent writings. The contraction theory has of late years been somewhat under a cloud, perhaps owing to the dominance of the idea of isostatic compensation as a general explanation of everything: it is notable that continental geologists in general attach much less importance to this theory than those of this country or of America.

Taken altogether, this book, which is written in an easy style with a refreshing absence of long and involved sentences, affords an extremely useful summary of the trend of thought among Austrian and German students of tectonics and can be strongly recommended to British readers.

R. H. R.

Special Reports on the Mineral Resources of Great Britain. Vol. XXIX. Iron Ores: Bedded Ores of England and Wales. Petrography and Chemistry. By A. F. Hallimond, with an Appendix by F. R. Ennos and R. Sutcliffe. pp. v + 139, with 8 plates and 3 text-figures. Mem. Geol. Survey, 1925. Price 3*s*. net.

FOR many years past there has been much discussion as to the origin of sedimentary ironstones in general and of the oolitic varieties in particular. Till recently the opinion certainly prevailed that oolitic ironstones were derived by metasomatic replacement from limestones at a date often long subsequent to their formation. The whole trend of recent work, however, has been to discredit this hypothesis; both Cayeux, in his monumental work on the Lorraine ores, and Hayes, in his descriptions of the Newfoundland stone, have pronounced strongly in favour of the view that they are now substantially in their original condition, and that the iron is essentially a primary constituent.

The painstaking and detailed work carried out by the author of this excellent memoir has led him to adopt a precisely similar view, and it really seems that the older metasomatic theory will have to be definitely abandoned, much as this is to be regretted, owing to its beautiful simplicity and air of probability, but facts are too strong for it, and experimental work yields only negative results.

In this work Mr. Hallimond has devised a scheme of classification for sedimentary iron ores, based solely on mineralogical and chemical characters without regard to theories of origin. In most cases the form in which the iron occurs has been definitely identified, and a clear distinction arises between the ferrous ores with siderite and chamosite on the one hand, and the ferric ores with limonite or other ferric oxide, magnetite, and pyrite. In all the green ores, whether oolitic or not, a chlorite, nearly always chamosite, is present. Thuringite has only been recognized doubtfully in the magnetite ore of Rosedale, an altogether peculiar and aberrant type. In the fresh Middle Lias and Inferior Oolite ores the iron is present as chamosite or siderite, usually both.

The conditions of formation of all the types are very fully discussed, some being marine, some freshwater (mainly from the Coal Measures), while some are assigned to the lagoon facies. This section is too long to be summarized here, and an abstract in any case would fail to do it justice. The chapter should be carefully read by all who are interested. Essentially all the ores are considered to be inorganic chemical precipitates, although it is recognized that bacteria or other organisms may have played an important part. The conditions of precipitation for each mineral are carefully considered on the basis of the ionization theory, and the whole subject is treated mainly from the chemical point of view, employing a very large number of new analyses carried out by methods devised by Messrs. Ennos and Sutcliffe, who contribute a useful appendix describing these methods. Many analyses from other sources are also utilized, being as a rule recalculated into minerals.

The memoir is illustrated by a large number of excellent photographs of micro-sections.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN. VOL. XXX: THE COPPER ORES OF THE MIDLANDS, WALES, THE LAKE DISTRICT, AND THE ISLE OF MAN. By H. DEWEY and T. EASTWOOD. pp. v + 87, with 6 plates. Mem. Geol. Survey, 1925. Price 2*s*. net.

IN this volume are gathered together accounts of all the copper ores of England and Wales not yet described in this series of Reports. They form rather a miscellaneous collection of widely scattered occurrence and varying origin, but show several points of interest. The most peculiar type is the copper ore disseminated in Trias sandstones, such as that of Alderley Edge. Of these a very full account is given, though no very definite conclusion is reached as to their origin, which is one of the puzzles of geology. Other small occurrences of the same kind are numerous in the Midlands, though of little importance.

Many of the more important copper deposits of the Lower Palaeozoic rocks also yield lead and zinc, so that there is bound to be a certain amount of overlap between different memoirs of this series, but this repetition has wisely been avoided as much as possible. The question of the age and relationships of these ore-deposits is still rather obscure, and its investigation is now rendered difficult by the closing of most of the mines. The writer of this review recently visited some of the old mines of the Lake District with a view to work on this point, but found little except scenes of desolation. It is difficult now to believe that 100 years ago British copper dominated the world's market; the Parys mine in Anglesey was perhaps then the most important copper mine in the world.

The authors of this memoir have done their work well in correlating all available information as to what appears to be a vanishing industry, and it will be of great value as a record and a starting point for new developments should conditions ever improve.

A STRATIGRAPHICAL SURVEY OF THE PLIOCENE DEPOSITS AT TJÖRNES, IN NORTHERN ICELAND. By G. G. BARDARSON. K. Dansk Vid. Selskab. (Biol. Medd., IV, 5), 1925. 118 pp., views, and section. Price 9 kr. 75.

MR. BARDARSON, who spent some months in England in 1924, has produced a valuable memoir on these late Tertiary beds, with a section between Kaldakvisl and Höskuldsvik at Tjörnes, on a scale of about 50 metres to 1 inch. He estimates the beds at

700 metres and puts the age of the fauna found therein as closely allied to that of the English crags. He gives an important table showing the geological age of the faunas of the *Cardium groenlandicum*, *Mactra*, and *Tapes* zones at Tjörnes, data of value for comparison with similar deposits elsewhere.

C. D. S.

CORRESPONDENCE.

FLORA OF PENNANT ROCK.

Sir,—I beg to record the occurrence of well-preserved petrified plant-remains in the Pennant Rock (probably Staffordian Series) of the Bristol and Somerset Coalfield.

Specimens were collected by Mr. Evens, B.Sc., of Bristol, from the Conygar Quarry, and by myself from the Hanham Quarry, and were submitted to Dr. D. H. Scott, F.R.S., who reports that they are of a general Cordaitean nature.

I have also to record the occurrence of petrified plants in the Pennant Rock of the South Wales Coalfield in the neighbourhood of Caerphilly.

The specimens referred to above will be described shortly.

Robert Crookall.

Botanical Department,
University of Bristol.

ANNOUNCEMENTS AND INQUIRIES.

AMALGAMATION OF THE IMPERIAL MINERAL RESOURCES BUREAU WITH THE IMPERIAL INSTITUTE.

In accordance with the Imperial Institute Act, 1925, the amalgamation of the Imperial Mineral Resources Bureau with the Imperial Institute took effect on the 1st July, 1925.

Inquiries and correspondence in connexion with the work of the Bureau should henceforward be addressed to the Imperial Institute (Mineral Resources Department), South Kensington, S.W. 7. Telephone number, Kensington 3798.

Dr. F. H. Hatch, who was a Governor of the Imperial Mineral Resources Bureau and a representative of the Mines Department on the Bureau's Committee, has been appointed one of the Board of Trade representatives on the Board of Governors of the Institute in respect of Mines.